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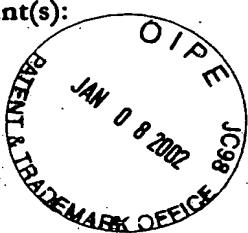
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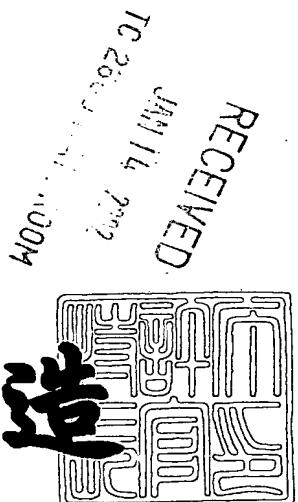
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駆動力伝達装置及びこれを用いた画像形

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【書類名】 明細書

【発明の名称】 駆動力伝達装置及びこれを用いた画像形成装置

【特許請求の範囲】

【請求項1】 一若しくは複数の無端状平ベルトを複数の張架部材に掛け渡すことで駆動力を伝達する駆動力伝達装置において、

平ベルトの少なくとも一つには平ベルトの進行方向に沿って複数列の貫通孔を設け、当該平ベルトが掛け渡される張架部材の少なくとも一つには平ベルトの貫通孔が嵌合する突起を当該張架部材の回転方向に沿って複数列設けたことを特徴とする駆動力伝達装置。

【請求項2】 請求項1記載の駆動力伝達装置において、

平ベルトの進行方向に直交する幅方向に対して隣接する貫通孔の各々は、平ベルトの進行方向に対して相互に重複しない位置に配置されていることを特徴とする駆動力伝達装置。

【請求項3】 駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる像担持体と、駆動源からの駆動力を像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、

駆動力伝達装置は、駆動源と像担持体との間に配設される複数の張架部材と、この複数の張架部材に掛け渡される一若しくは複数の無端状平ベルトとを備え、

平ベルトの少なくとも一つには進行方向に沿って複数列の貫通孔を設け、平ベルトが掛け渡される張架部材の少なくとも一つには平ベルトの貫通孔が嵌合する突起を当該張架部材の回転方向に沿って複数列設けたことを特徴とする画像形成装置。

【請求項4】 一若しくは複数の無端状平ベルトを複数の張架部材に掛け渡すことで駆動力を伝達する駆動力伝達装置において、

駆動力が伝達せしめられる張架部材の少なくとも一つに当該張架部材の回転軸に対して同軸で且つ自由回転可能な自由回転体を設け、この自由回転体が設けられた張架部材とは異なって隣接する張架部材に対し平ベルトを前記自由回転体を介して掛け渡すようにしたことを特徴とする駆動力伝達装置。

【請求項5】 請求項4記載の駆動力伝達装置において、

平ベルトの少なくとも一つには進行方向に沿って一若しくは複数列の貫通孔を設け、当該平ベルトが掛け渡される張架部材の少なくとも一つには平ベルトの貫通孔が嵌合する突起を設けたことを特徴とする駆動力伝達装置。

【請求項6】 請求項4記載の駆動力伝達装置において、

自由回転体は、張架部材の回転軸の軸方向に対し位置規制部材にて位置規制されていることを特徴とする駆動力伝達装置。

【請求項7】 請求項4記載の駆動力伝達装置において、

自由回転体は、掛け渡される平ベルトの進行方向に直交する幅方向に対する位置を規制する位置規制部を具備していることを特徴とする駆動力伝達装置。

【請求項8】 駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる像担持体と、駆動源からの駆動力を像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、

駆動力伝達装置は、駆動源と像担持体との間に配設される複数の張架部材と、この複数の張架部材に掛け渡される一若しくは複数の無端状平ベルトとを備え、

駆動力が伝達せしめられる張架部材の少なくとも一つに当該張架部材の回転軸に対して同軸で且つ自由回転可能な自由回転体を設け、この自由回転体が設けられた張架部材とは異なって隣接する張架部材に対し平ベルトを前記自由回転体を介して掛け渡すようにしたことを特徴とする画像形成装置。

【請求項9】 一若しくは複数の無端状平ベルトを複数の張架部材に掛け渡すことで駆動力を伝達する駆動力伝達装置において、

平ベルトの少なくとも一つには、平ベルトの進行方向に直交する幅方向に延びる長孔状貫通孔を平ベルトの進行方向に沿って設け、当該平ベルトが掛け渡される張架部材の少なくとも一つには、平ベルトの長孔状貫通孔が嵌合し且つ張架部材の回転方向に直交する幅方向に延びる柱状突起を当該張架部材の回転方向に沿って設けたことを特徴とする駆動力伝達装置。

【請求項10】 駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる像担持体と、駆動源からの駆動力を像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、

駆動力伝達装置は、駆動源と像担持体との間に配設される複数の張架部材と、

この複数の張架部材に掛け渡される一若しくは複数の無端状平ベルトとを備え、平ベルトの少なくとも一つには、平ベルトの進行方向に直交する幅方向に延びる長孔状貫通孔を平ベルトの進行方向に沿って設け、当該平ベルトが掛け渡される張架部材の少なくとも一つには、平ベルトの長孔状貫通孔が嵌合し且つ張架部材の回転方向に直交する幅方向に延びる柱状突起を当該張架部材の回転方向に沿って設けたことを特徴とする画像形成装置。

【請求項11】 請求項9記載の駆動力伝達装置のうち、平ベルトの少なくとも一つは、長孔状貫通孔又は長孔状貫通孔及び円形貫通孔を有し、張架部材の少なくとも一つは、長孔状貫通孔に嵌合する柱状突起、及び、長孔状貫通孔又は円形貫通孔に嵌合する略半球状突起を有する態様であって、

柱状突起と長孔状貫通孔の平ベルトの進行方向における縁部との隙間をd1、柱状突起と長孔状貫通孔の平ベルトの幅方向における縁部との隙間をd2、略半球状突起と長孔状又は円形貫通孔の平ベルトの幅方向における縁部との隙間をd3とすると、 $d1 \leq d3 \leq d2$ の関係を満たすことを特徴とする駆動力伝達装置。

【請求項12】 駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる像担持体と、駆動源からの駆動力を像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、

駆動力伝達装置は、駆動源と像担持体との間に配設される複数の張架部材と、この複数の張架部材に掛け渡される一若しくは複数の無端状平ベルトとを備え、請求項11記載の駆動力伝達装置を用いたことを特徴とする画像形成装置。

【請求項13】 請求項1、4又は9記載の駆動力伝達装置において、平ベルトの少なくとも一つは、同一材料又は略同一な材料特性を有する複数のベルト材を、少なくとも一部が固定され且つ相互に独立伸縮可能に重合配置したことを特徴とする駆動力伝達装置。

【請求項14】 駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる複数系統の像担持体と、駆動源からの駆動力を複数系統の像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、複数系統の像担持体のうち回転負荷の最も大きい系統の像担持体へ駆動力を伝

達する駆動力伝達装置として、請求項1、4又は9記載の駆動力伝達装置を用いたことを特徴とする画像形成装置。

【請求項15】 請求項3、8又は10記載の画像形成装置のうち、二系統の像担持体を備えた画像形成装置において、

駆動力伝達装置は、一の駆動源から第一系統の像担持体へ駆動力を伝達する第一平ベルトと、一の駆動源から第二系統の像担持体へ駆動力を伝達する第二平ベルトとを備えたことを特徴とする画像形成装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】

本発明は、複写機、プリンタ、ファクシミリ若しくはこれらの複合機のような画像形成装置などに用いられる駆動力伝達装置に係り、特に、無端状平ベルトを複数の張架部材に掛け渡すことで駆動力を伝達する駆動力伝達装置及びこれを用いた画像形成装置の改良に関する。

【0002】

【従来の技術】

プリンタや複写機等の画像形成装置に利用される駆動力伝達装置には、その不良が直ちに画像欠陥へと繋がるという性質上、高噛み合い率、高伝達性、回転ムラの抑制など、様々かつ高度な要求を満たすことが求められている。

従来における画像形成装置の駆動力伝達装置として、高噛み合い率と高伝達率の実現、あるいは良好な低回転ムラ性能を得るために、はす歯歯車を用いて像担持体ドラムへ駆動力を伝達する技術が提案されている（例えば特開平9-80840号公報、特開平5-72862号公報参照）。

また、はす歯歯車を用いるよりも低回転ムラ性能が実現できる駆動力伝達部材として、歯付きベルトを用いる技術も提案されている。

更に、歯付きベルトより低回転ムラを実現するために、はす歯ベルトを用いる技術も提案されている（例えば特開平9-160332号公報、特開平10-26903号公報参照）。

【0003】

一般に、駆動力伝達部材として、はす歯歯車を用いた場合は、すぐ歯歯車を用いた場合と比較して噛み合い率を大きく取り易く、駆動歯車と従動歯車との噛み合いがゆっくりと行われるため、従動歯車に伝達される噛み合い振動をかなり低減することが可能であることが分かっている。しかし、歯車を駆動力伝達部材として用いた場合には、バックラッシュによる回転ムラの発生という技術的課題は避けられない。

すなわち、駆動歯車が従動歯車と噛み合って従動歯車を回転駆動する際に、駆動歯車の歯と従動歯車の歯とは所定の時間だけ互いに接触しているが、その時間が過ぎ、次の歯同士が噛み合うまでの間にお互いの歯同士が非接触状態になり、これがバックラッシュ（がた）である。このため、バックラッシュは、次の歯同士が噛み合う時に振動を発生させ、従動歯車には周期的（歯車の歯同士が噛み合う繰り返し）な回転ムラが発生する要因になってしまう。

このバックラッシュは、歯車を用いる場合には原理的に避けられないものであり、画像形成装置の駆動力伝達部材として歯車を用いた場合には、従動歯車が噛み合いによって加振され、非拘束状態となるバックラッシュ分だけ容易に動かされてしまうため、噛み合い振動による小さな加振力でも出力画像に周期的な濃度ムラを発生させてしまうことになる。

【0004】

また、はす歯歯車を用いたとしても、すぐ歯歯車を用いた場合と比較して、噛み合い歯数を大幅に増やすことは不可能であるため、歯の変形問題を考慮すると、特に噛み合い接触部においてある程度の硬度を有する材料で歯車を製作する必要がある。

しかし、硬度の高い材料で形成された駆動歯車と従動歯車とが噛み合う場合には、噛み合いによって生じる振動を吸収する部分が駆動力伝達経路内（歯車列により幾つかの回転体を駆動する場合の伝達経路内）に存在しなくなるため、駆動歯車と従動歯車とが噛み合うことにより発生する噛み合い振動は減衰されずにそのまま従動歯車へ伝達され、その結果、出力画像に周期的な濃度ムラが発生するという技術的課題もある。

【0005】

一方、歯付きベルトを用いた駆動力伝達装置では、ブーリと噛み合う歯付きベルトの歯が柔軟性に富んだゴム径の材料で製作されているため、ブーリと歯付きベルトとの噛み合い振動は歯車よりも少ないと期待される。しかし、実測を行った結果は、次に示すように歯車とほとんど変わらない結果であった。

すなわち、図31は、駆動力伝達部材としてすぐ歯ベルト及びすぐ歯歯車を用いた場合の回転ムラを示す図である。

図31から分かるように、すぐ歯ベルトを用いても、すぐ歯歯車の回転ムラとほとんど変わらない結果しか得られていない。

確かに、回転ムラは歯のピッチを細かくすることにより改善されるが、あまり細かくすると負荷増加による歯飛び現象が生じ駆動不可能となるため、大きな改善は望めない。従って、すぐ歯ベルトを用いても、出力画像の濃度ムラ発生を防止することはできないことになる。

【0006】

図32は、カラープリンタなどの画像形成装置において濃度ムラ許容値と像担持体ドラムの回転ムラとの関係を示す。

同図において、出力画像の濃度ムラが認知可能となる像担持体ドラムの回転ムラレベルは、回転ムラの指標となる速度変動率 ΔV_{0-p} （%）において約0.3%であり、これ以上の速度変動率が発生すると出力画像の濃度ムラが問題となってしまう。そのため、歯車や歯付きベルトにおける噛み合い振動レベルは、この濃度ムラという観点からは非常に大きな問題となる。

すなわち、画像形成装置としての回転ムラ要求は非常に高度なレベルが要求され、はす歯ベルトを用いた場合でも歯飛び現象などすぐ歯ベルト同様に生じるため、図31に示すすぐ歯ベルトの回転ムラレベルを許容値以下に改善するのは困難である。

【0007】

そこで、このような技術的課題を解決するための先行技術としては、例えば複数の像担持体ドラムの外周面を夫々同量移動させる駆動力伝達装置として、駆動ブーリと従動ブーリとの間に無端状の平ベルトを掛け渡すことで駆動力を伝達するものが既に提案されている（例えば特開平7-319254号公報参照）。

このタイプによれば、平ベルトとプーリ（駆動プーリ及び従動プーリ）との間は摩擦力で駆動伝達されるため、平ベルトとプーリとの間で、歯車や歯付きベルトのような噛み合いにより発生する噛み合い振動は原理的に生じない。このため、歯車や歯付きベルトを用いた場合のように、周期的な濃度ムラが出力画像に発生することは有效地に防止される。

【0008】

【発明が解決しようとする課題】

しかしながら、従来この種の平ベルトを用いた駆動力伝達装置にあっては、平ベルトとプーリとの間の駆動力伝達が摩擦伝達になるため、平ベルトとプーリとの間で滑りという新たな技術的課題が生ずる。

ここで、図33は平ベルトを用いた駆動力伝達装置における従動プーリの平均回転速度と負荷トルクとの関係を示すグラフである。

図33に示すように、従動プーリの平均回転速度は、負荷トルクがある限界値を超えると急激に低下する。これは、従動プーリ軸（従動軸）負荷の増加に伴い定常滑り量も増加していき、負荷がある限界値以上になると平ベルトと駆動プーリあるいは従動プーリ間の滑りが急激に大きくなり、従動プーリ平均回転速度が大きく低下するためである。

【0009】

このような状態になる従動プーリ軸の負荷量近傍で駆動を行っていると、従動プーリの速度は時間とともに不安定な状態となり、その結果、出力画像に色ずれや転写ムラが発生して正常な画像形成動作を行うことはできなくなる。最悪の場合には、画像形成装置が停止あるいは故障を引き起こすこととなる。

また、負荷トルクの限界値を向上するためには、ベルト初期張力を増やすことが効果的である。すなわち、ベルト初期張力を増やすことによりベルトをプーリに押し付ける力が大きくなり、その結果、摩擦駆動力が増加することから、負荷トルクの限界値は増加していく。

しかし、ゴムベルトや樹脂ベルトを用いた場合には、ベルト自体の剛性が低く、大きな張力を付与することは不可能である。そのため、駆動力伝達系の剛性を確保し安定した駆動力を得る目的で金属ベルトを利用することが考えられている

が、金属ベルトとブーリ間の摩擦係数は、ゴムベルトや樹脂ベルトとブーリ間の摩擦係数と比較して極端に小さいため、図33に示すように、従動ブーリ軸負荷の限界値が大きく改善されることではなく、倍の張力を与えても、目標とする画像形成装置の負荷量で駆動することはできなかった。

【0010】

また、金属ベルトを用いて負荷トルクの限界値を向上させるために、非常に大きなベルト初期張力を付与した場合には、ブーリを支持する軸が撓み、各ブーリ軸のアライメントがずれ、ベルトに大きな蛇行が発生した。これにより、平ベルトがブーリに設けたベルトエッジガイドに対し大きな力で擦られるため、ベルト端部に歪みが生じ不安定な駆動となってしまった。

従って、現実の画像形成装置において想定されるような従動負荷条件の下では安定した画像形成動作が不可能になるという致命的な欠陥があり、これもまた満足すべき解決策とはなり得ない。

【0011】

更に、ブーリへのベルト巻き付け角度を大きくすることで張力によるブーリへのベルト押し付け力を大きくすることが可能になるため、ブーリへのベルト巻き付け角度を増やすこともベルトの滑りに対し効果がある。

例えば図34に示すように、複数の感光体ドラムの駆動力伝達装置として、感光体ドラム500(500Y, 500M, 500C, 500K)と同軸に駆動用ブーリ(図示せず)を設け、この駆動用ブーリに平ベルト510を巻き付ける構成において、駆動及び従動用の張架ブーリ501, 502の他に、いくつかの補助張架ブーリ511～515を設けることにより、感光体ドラム500の駆動用ブーリへの平ベルト510の巻き付け角度を大きく確保する技術が既に提案されている(例えば特開平7-319254号公報、特開平10-111586号公報、特開平10-161384号公報参照)。尚、図34中、符号505は中間転写用あるいは用紙搬送用のベルトユニットである。

ところが、このタイプにあっては、ベルト(平ベルト510)を張架するためにスペースを大きくとる必要が生じたり、補助張架ブーリ511～515用支持部材を設ける必要が生じ、小型・低コストの観点からすれば、このような構成は

好ましいものとは言えない。

【0012】

そこで、本発明者らは、例えばカラー画像形成装置の像担持体ドラムの駆動力伝達装置として、所謂パーフォレーションベルトを使用する態様について検討した。

図35(a) (b) はパーフォレーションベルトを使用した駆動力伝達装置の概要を示すものであり、パーフォレーションベルト600(具体的には循環移動方向に沿って所定ピッチ間隔で貫通孔602が配列された平ベルト601[孔付き平ベルト])を駆動あるいは従動ブーリ603に掛け渡し、このブーリ603の外周面には前記貫通孔602に対応する突起604を設け、平ベルト601の貫通孔602にブーリ603の突起604を嵌合させ、パーフォレーションベルト600を循環移動させるものである。

【0013】

このようなタイプにあっては、従来の歯車や歯付きベルトを利用して駆動力を伝達する態様に比べて、貫通孔と突起との噛み合い時のバックラッシュがなく(貫通孔と突起にクリアランスが存在していてもベルト自体がブーリに巻き付けられているため非拘束状態とはならない)、噛み合い時の振動が低減でき、出力画像に周期的な濃度ムラなどの画像欠陥が発生するのを防止することができる。

また、各ブーリ603の突起604と平ベルト601の貫通孔602とが互いに嵌合することにより駆動力を伝達するため、従来の平ベルトとブーリとの摩擦により駆動力を伝達する場合に比べて、大きな負荷が加わる場合であっても平ベルトとブーリとが滑ることがなく、出力画像に色ずれや転写ムラなどの画像欠陥が発生するのを防止することができる。

図36はパーフォレーションベルトを用いた駆動力伝達装置における従動ブーリ軸負荷と従動ブーリ平均回転速度との関係を示す。

同図によれば、パーフォレーションベルト(孔付き平ベルト)による駆動力伝達を行うことにより、通常の平ベルトと比べ高い負荷が加わった状態においても、滑りによる平均速度の低下を招くことはないことが理解される。

【0014】

また、このようなパーフォレーションベルトを使用した駆動力伝達装置を用いれば、平ベルトやブーリとして使用する材質の幅を広げることができる。つまり、従来の平ベルトとブーリとの摩擦により駆動力を伝達する場合には、必然的に摩擦係数の高い材質（例えば、樹脂）を使用する必要があり、摩擦係数の低い材質（例えば、金属）などを使用することは実質的に不可能であった。

しかし、このようなパーフォレーションベルトを使用する態様では、各ブーリ603の突起604と平ベルト601の貫通孔602とが互いに嵌合することにより駆動力を伝達するため、摩擦係数の高低に関係なく、より適切な材質を選択することができる。

【0015】

しかし、パーフォレーションベルトを用いた駆動力伝達装置では、通常の平ベルトを用いた態様で発生する滑りを、平ベルトの貫通孔とブーリに設けた突起との噛み合いにより防止しているため、従動ブーリ軸に大きな負荷トルクがかかると、貫通孔と突起との噛み合いにかかる力が大きくなり、薄いベルトでは貫通孔の歪みが増大し、貫通孔部又は突起が破壊される現象が生じる。通常、突起部には剛球が用いられており、破壊が生じるのはパーフォレーションベルトの貫通孔部である。

ここで、パーフォレーションベルトの貫通孔の破壊を防止するためには、ブーリ径を大きくしベルトの引っ張り負荷を小さくすることや、ベルトの厚みを多くすること、貫通孔及びブーリに設けた突起のピッチ間隔を狭め、駆動ブーリ及び従動ブーリにパーフォレーションベルトが巻きかかる領域内での噛み合い数を多くすることが考えられる。

【0016】

しかしながら、この種の駆動力伝達装置を近年のカラー画像形成装置等に適用しようとする場合には、カラー画像形成装置は近年小型化が進んできている関係上、ブーリ径を劇的に大きくすることは不可能であり、また、これに伴いベルトの厚みを多くするとベルトの剛性が増し、小径のブーリにパーフォレーションベルトが巻きかからないといった技術的課題が生じてくる。

また、貫通孔や突起の間隔を狭くしていくと、各貫通孔で生じる歪みを貫通孔

間で吸収できなくなり、結果として貫通孔部を破壊することになってしまう。

更に、貫通孔部の破壊は従動ブーリ軸の負荷トルクによるものだけでなく、ベルト蛇行によっても生じる。

【0017】

すなわち、パフォレーションベルトによる駆動力伝達方式は、平ベルト同様にベルト初期張力を上げることで従動ブーリ軸の負荷トルク限界値を向上することができる。そのため、ある程度の大きさでベルト張力を与えることが好ましいが、張力を与えたことにより各ブーリ軸アライメントずれが生じ、ベルトの蛇行を発生させてしまう。平ベルトはガイドによって蛇行を防止することができるが、パフォレーションベルトによる駆動力伝達方式では、貫通孔部と突起とのクリアランスを必要以上に大きくすることは回転ムラに対し好ましくないため、パフォレーションベルトが掛け渡されるブーリにガイドを設けることは一般に困難である。

そのため、貫通孔部は、従動ブーリ軸の負荷トルクと同様、ベルト蛇行に対しても駆動中常に蛇行方向に対し力を受けることになり、負荷トルクによる回転方向での力と合わせて非常に破壊されやすい状況となってしまう。また、負荷トルクの変化によるベルト張力変化などによっても蛇行の程度が変化し、破壊現象が生じてしまう。

【0018】

本発明は、以上の技術的課題を解決するためになされたものであって、複数の張架部材に無端状の平ベルトを掛け渡す態様において、ブーリ等の張架部材と平ベルトとの間の滑りによる駆動力の伝達誤差をなくし、しかも、被駆動体に大きな負荷がかかる状態であっても、駆動力を安定的に伝達することを可能とした駆動力伝達装置及びこれを用いた画像形成装置を提供するものである。

【0019】

【課題を解決するための手段】

すなわち、本発明は、図1に示すように、一若しくは複数の無端状平ベルト1を複数の張架部材2（例えば2a～2d）に掛け渡すことで駆動力を伝達する駆動力伝達装置において、平ベルト1の少なくとも一つには平ベルト1の進行方向

に沿って複数列の貫通孔3を設け、当該平ベルト1が掛け渡される張架部材2の少なくとも一つには平ベルト1の貫通孔3が嵌合する突起4を当該張架部材2の回転方向に沿って複数列設けたことを特徴とするものである。

そして、図1においては、例えば一つの張架部材2aに図示外の駆動源からの駆動力が伝達されると、この張架部材2aを介して平ベルト1に駆動力が伝達され、この平ベルト1を介して例えば張架部材2b, 2cと同軸に設けられた被駆動体(図示せず)に駆動力が伝達される。

【0020】

このような技術的手段において、無端状平ベルト1としては单一のものに限られず、複数のものを用いる態様であってもよい。

また、張架部材2は平ベルト1を張架するものであればよく、ブーリ、ロールなど広く含む。

更に、安定的に駆動力を伝達する観点からは、駆動力伝達装置を構成する各部材の剛性は高いことが好ましい。従って、上記平ベルト1、張架部材2が剛性の高い材質、例えば金属により構成されることが好ましく、金属の種類としては耐久性などの観点からステンレスが好ましい。

更にまた、平ベルト1は進行方向に沿って貫通孔3を配列したものであり、各貫通孔3は、回転する張架部材2に設けられた突起4に嵌合するものであるため、平ベルト1の進行方向に沿って所定ピッチ間隔に設けられる。

そして、突起4と貫通孔3との形状は任意であるが、両者の嵌合性を考慮すると、一般的には突起4の形状は略半球であり、貫通孔3は円形のものを採用することが好ましい。

【0021】

特に、本発明においては、平ベルト1の貫通孔3は平ベルト1の進行方向に沿って複数列設けられていればよい。

ここで、「平ベルト1の進行方向に沿って複数列設ける」とは、平ベルト1の進行方向に直交する幅方向に対して複数列配列することを意味し、その配列方法については任意である。

このように、貫通孔3を複数列設けるようにすれば、被駆動体に連結される張

架部材2（例えば2b, 2c）の軸に大きな負荷トルクがかかったとしても、複数列の貫通孔3部で力を分散して受け止めることができ、貫通孔3部での破壊を有効に防止することができる。

【0022】

また、貫通孔3の好ましい配列については、平ベルト1の進行方向に直交する幅方向に対して隣接する貫通孔3の各々は、平ベルト1の進行方向に対して相互に重複しない位置に配置されていることが好ましい。

このようにすれば、貫通孔3間のベルト剛性を確保することで、ベルト初期張力として大きな張力を与えても、ベルト蛇行による貫通孔3部の破壊を有効に防止できる。

【0023】

更に、上述した駆動力伝達装置に係る発明を画像形成装置に適用すると、以下のようになる。

すなわち、本発明に係る画像形成装置は、駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる像担持体と、駆動源からの駆動力を像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、駆動力伝達装置には、図1に示すように、駆動源と像担持体との間に配設される複数の張架部材2と、この複数の張架部材2に掛け渡される一若しくは複数の無端状平ベルト1とを備え、平ベルト1の少なくとも一つには進行方向に沿って複数列の貫通孔3を設け、平ベルト1が掛け渡される張架部材2の少なくとも一つには平ベルト1の貫通孔3が嵌合する突起4を当該張架部材2の回転方向に沿って複数列設けたものである。

ここで、像担持体としては、感光体の他、中間転写体や用紙等のシート搬送体も含まれ、これらの形態としては、ドラム状（円筒状）のものの他、無端ベルト状のものも含まれる。

【0024】

このような画像形成装置によれば、上述の駆動力伝達装置を画像形成装置として適用する場合には、従来の歯車や歯付きベルトを利用して駆動力を伝達する様に比べて、噛み合いの振動がなく、出力画像に周期的な濃度ムラなどの画像欠

陥が発生するのを防止することができる。

また、各張架部材2の突起4と平ベルト1の貫通孔3とが互いに嵌合することにより駆動力を伝達するため、従来の平ベルトとプーリとの摩擦により駆動力を伝達する場合に比べて、大きな負荷が加わる場合であっても平ベルトとプーリととが滑ることがなく、かつ、より大きな負荷が加わった場合であっても、貫通孔3部が破壊することなく、出力画像に色ずれや転写ムラなどの画像欠陥が発生するのを防止することができ、安定した画像形成動作を行わせることができるとなる。

【0025】

更に、省エネルギーとコスト軽減の観点から、像担持体のみならず、転写ロール、帶電ロールなどの像担持体と接触して従動回転する回転体をも含めて单一の駆動源で回転駆動させる場合や、これらの像担持体や他の回転体の軸受が部品点数軽減のためにペアリング等の転がり軸受ではなくすべり軸受が採用される場合に、像担持体の回転負荷は増大する傾向にある。従って、このような画像形成装置に本発明を適用することが好ましい。

【0026】

また、画像形成装置の中には複数系統の像担持体を備えるものが存在する。

ここで、回転負荷の大きい場合でも平ベルト1とプーリ等の張架部材2との間で滑りが生ぜず、平ベルト1の貫通孔3部の破壊も防止でき、出力画像に色ずれや転写ムラなどの画像欠陥が発生しないという本発明の利点を生かすためには、より回転負荷の大きい系統の像担持体に本発明を適用することが好ましい。

このような場合、本発明は、駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる複数系統の像担持体と、駆動源からの駆動力を複数系統の像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、複数系統の像担持体のうち回転負荷の最も大きい系統の像担持体へ駆動力を伝達する駆動力伝達装置として、図1に示す駆動力伝達装置を用いるようにすればよい。

本態様において、「回転負荷の最も大きい系統の像担持体へ駆動力を伝達する駆動力伝達装置」とは、ある系統の像担持体が複数あり、各像担持体への駆動力

伝達系が並列的に設けられるものであれば対象となる像担持体に対する駆動力伝達系を指す。また、ある系統の像担持体が複数あり、各像担持体への駆動伝達系が直列的に設けられるものであれば回転負荷の最も大きい像担持体を含む複数の像担持体への駆動力伝達系全体を指す。

【0027】

更に、単一の駆動源により複数系統の像担持体などを回転駆動させる場合に、一つの系統の像担持体へ加わる外乱（例えば、クリーニング装置、転写装置の接触や離間、記録シート上への乗り上げや乗り下げなど）が、他の像担持体へ影響を与えててしまう虞れがある。

このような場合、本発明は、二系統の像担持体を備えた画像形成装置において、駆動力伝達装置としては、一の駆動源から第一系統の像担持体へ駆動力を伝達する第一平ベルトと、一の駆動源から第二系統の像担持体へ駆動力を伝達する第二平ベルトとを備えるようにすればよい。

このように画像形成装置を構成することにより、第一系統の像担持体へ何らかの外乱が加わり、その外乱が第一平ベルトを介して駆動源に伝達されても、駆動源はその特性〔具体的には、駆動源は、自ら駆動トルク（第一の平ベルトと第二の平ベルトに掛かる負荷トルクの合計）を発生させ回転しており、従動プーリが直接平ベルトから外乱（トルク変動）を受けるより、DC的に大きなトルク発生源を通過させる方が、駆動源の保持力が利くため外乱に対する影響が小さい〕により当該外乱を打ち消し、第二平ベルトを介して第二系統の像担持体へその外乱が伝達されることはない。逆に、第二系統の像担持体へ外乱が加わる場合も同様である。

【0028】

ここで、二系統の像担持体の関係としては、例えば、①第一系統の像担持体は記録シートが直接接觸するものであり、第二系統の像担持体は直接接觸しないもの、②第一系統の像担持体表面に保持されるトナー像と第二系統の像担持体表面に保持されるトナー像との色が相異なるもの、③第一系統の像担持体にはクリーニング装置が当接離間しないが、第二系統の像担持体には当接離間するもの、④第一系統の像担持体には転写装置が当接離間しないが、第二系統の像担持体には

当接離間するもの、⑤これら第一及び第二系統の像担持体にクリーニング装置や転写装置が当接離間するタイミングが夫々異なるものなどの態様が挙げられる。

【0029】

また、本発明に係る駆動力伝達装置の別の態様は、図2(a)に示すように、一若しくは複数の無端状平ベルト1を複数の張架部材2(例えば2a～2d)に掛け渡すことで駆動力を伝達する駆動力伝達装置において、平ベルト1の少なくとも一つには、平ベルト1の進行方向に直交する幅方向に延びる長孔状貫通孔3aを平ベルト1の進行方向に沿って設け、当該平ベルト1が掛け渡される張架部材2の少なくとも一つには、平ベルト1の長孔状貫通孔3aが嵌合し且つ張架部材2の回転方向に直交する幅方向に延びる柱状突起4aを当該張架部材2の回転方向に沿って設けたことを特徴とするものである。

【0030】

このような技術的手段においては、平ベルト1や張架部材2の素材については、図1に示す態様と同様である。

また、平ベルト1は進行方向に沿って長孔状貫通孔3aを配列したものであり、各貫通孔3aは、回転する張架部材2に設けられた柱状突起4aに嵌合するものであるため、平ベルト1の進行方向に沿って所定ピッチ間に設けられる。

ここで、長孔状貫通孔3aの形状は、通常長手方向に直線部を有しているが、曲線部を有したものも含む。

一方、柱状突起4aの形状は、通常略半円柱形状であるが、長孔状貫通孔3aに対する係脱動作がスムーズに行われるものであれば、この形状に限定されない。

更に、本態様は、長孔状貫通孔3a、柱状突起4aを具備した態様を全て含む趣旨であり、長孔状貫通孔3a以外に円形貫通孔3b(例えば図2(b)参照)を設けたり、柱状突起4a以外に略半球状突起4b(例えば図2(b)参照)を設けるという態様も含む。

【0031】

このように、長孔状貫通孔3aを設けるようにすれば、被駆動体に連結される張架部材2(例えば2b、2c)の軸に大きな負荷トルクがかかったとしても、

平ベルト1の長孔状貫通孔3aと張架部材2の柱状突起の噛み合い方は、径差を持つ円筒孔(円形の貫通孔と半球状の突起)の点接触ではなく、長孔状貫通孔3aの長手方向線状部(直線部若しくは曲線部)と張架部材2の柱状突起4aの線状部との線接触部で力を分散して受け止めることができ、長孔状貫通孔3a部での破壊を有効に防止することができる。

【0032】

また、更に、上述した駆動力伝達装置に係る発明を画像形成装置に適用すると、以下のようなになる。

すなわち、本発明に係る画像形成装置は、駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる像担持体と、駆動源からの駆動力を像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、駆動力伝達装置には、図2(a)に示すように、駆動源と像担持体との間に配設される複数の張架部材2と、この複数の張架部材2に掛け渡される一若しくは複数の無端状平ベルト1とを備え、平ベルト1の少なくとも一つには、平ベルト1の進行方向に直交する幅方向に延びる長孔状貫通孔3aを平ベルト1の進行方向に沿って設け、当該平ベルト1が掛け渡される張架部材2の少なくとも一つには、平ベルト1の長孔状貫通孔3aが嵌合し且つ張架部材2の回転方向に直交する幅方向に延びる柱状突起4aを当該張架部材2の回転方向に沿って設けたものである。

ここで、像担持体としては、感光体の他、中間転写体や用紙等のシート搬送体も含まれ、これらの形態としては、ドラム状(円筒状)のものの他、無端ベルト状のものも含まれる。

本態様にあっても、図1に示す態様と同様な作用、効果を奏するものである。

【0033】

また、本態様の駆動力伝達装置のうち、図2(a)(b)に示すように、平ベルト1の少なくとも一つが、長孔状貫通孔3a又は長孔状貫通孔3a及び円形貫通孔3bを有し、張架部材2の少なくとも一つが、長孔状貫通孔3aに嵌合する柱状突起4a、及び、長孔状貫通孔3a又は円形貫通孔3bに嵌合する略半球状突起4bを有する態様があり得る。

このとき、円形貫通孔3bを設ける態様にあっては、この円形貫通孔3bは所

定ピッチ間隔毎に設けられ、これに対応して略半球状突起4 bを設けるようにすればよい。

この場合において、柱状突起4 aと略半球状突起4 bとのレイアウトについては、1つ置きでもよいし、あるいは、二つ置きなど適宜選定して差し支えないし、また、数についても必ずしも同数である必要はなく、適宜比率で配分して差し支えない。

【0034】

更に、円形貫通孔3 bを設けない態様にあっては、長孔状貫通孔3 aに略半球状突起4 bを嵌合させることになるが、この場合、柱状突起4 aと略半球状突起4 bとが嵌合する長孔状貫通孔3 aの形状を相互に変えて差し支えないが、平ベルト1の構成を簡略化するという観点からすれば、同一構成の長孔状貫通孔3 aを用いることが好ましい。

また、長孔状貫通孔3 aに嵌合する略半球状突起4 bについては、長孔状貫通孔3 aの長手方向両側に通常一対設けられるが、必ずしもこれに限定されるものではなく、3以上設けるようにしても差し支えない。

【0035】

このような態様において、図2 (a) (b)に示すように、柱状突起4 aと長孔状貫通孔3 aの平ベルト1の進行方向における縁部との隙間をd1、柱状突起4 aと長孔状貫通孔3 aの平ベルト1の幅方向における縁部との隙間をd2、略半球状突起4 bと長孔状又は円形貫通孔3 a又は3 bの平ベルト1の幅方向における縁部との隙間をd3とすると、 $d1 \leq d3 \leq d2$ の関係を満たすことが好ましい。

この場合、柱状突起4 aは、主として張架部材2に作用する負荷トルクに対して作用力を分散させるものであり、略半球状突起4 bは主として平ベルト1の蛇行方向に対する位置規制を行うものである。

このため、平ベルト1の蛇行を有効に回避しながら、負荷トルクの分散を図り、貫通孔部(長孔状貫通孔3 a、円形貫通孔3 b)の破壊を防止することが可能になる。

【0036】

また、本発明は、上述した関係 ($d_1 \leq d_3 \leq d_2$) を満たす駆動力伝達装置を組み込んだ画像形成装置をも対象とする。

この場合、本発明はとしては、駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる像担持体と、駆動源からの駆動力を像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、駆動力伝達装置には、図2(a) (b) に示すように、駆動源と像担持体との間に配設される複数の張架部材2と、この複数の張架部材2に掛け渡される一若しくは複数の無端状平ベルト1とを具備させ、上述した関係 ($d_1 \leq d_3 \leq d_2$) を満たす駆動力伝達装置を用いるようにすればよい。

【0037】

また、画像形成装置の中には複数系統の像担持体を備えるものが存在するが、図1に示す駆動力伝達装置を組み込んだ画像形成装置と同様に、回転負荷の大きい系統の像担持体に本発明を適用することが好ましい。

このような場合、本発明は、駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる複数系統の像担持体と、駆動源からの駆動力を複数系統の像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、複数系統の像担持体のうち回転負荷の最も大きい系統の像担持体へ駆動力を伝達する駆動力伝達装置として、図2に示す駆動力伝達装置を用いるようにすればよい。

更に、単一の駆動源により二系統の像担持体を回転駆動させる場合には、本発明は、二系統の像担持体を備えた画像形成装置において、駆動力伝達装置としては、一の駆動源から第一系統の像担持体へ駆動力を伝達する第一平ベルトと、一の駆動源から第二系統の像担持体へ駆動力を伝達する第二平ベルトとを備えるようにすればよい。

【0038】

また、本発明に係る駆動力伝達装置の更に別の態様は、図3に示すように、一若しくは複数の無端状平ベルト1を複数の張架部材2(例えば2a～2c)に掛け渡すことで駆動力を伝達する駆動力伝達装置において、駆動力が伝達せしめられる張架部材2の少なくとも一つ(例えば2a)に当該張架部材2aの回転軸に

対して同軸で且つ自由回転可能な自由回転体5を設け、この自由回転体5が設けられた張架部材2（例えば2a）とは異なって隣接し合う張架部材2（例えば2b, 2c）に対し平ベルト1を前記自由回転体5を介して掛け渡すようにしたことを特徴とするものである。

【0039】

そして、図3においては、張架部材2（例えば2a）に駆動力が伝達せしめられると、この張架部材2aを介して平ベルト1に駆動力が伝達され、この平ベルト1を介して例えば張架部材2b, 2cと同軸に設けられる被駆動体（図示せず）に駆動力が伝達される。

このとき、平ベルト1は張架部材2b, 2cに対し自由回転体5を介して掛け渡されているため、平ベルト1の張架部材2b, 2cへの巻き付け角度は充分に大きく確保され、平ベルト1と被駆動体が連結された張架部材2b, 2cとの間の摩擦抵抗は充分に大きなものになり、平ベルト1からの駆動力が張架部材2b, 2cに確実に伝達される。

一方、自由回転体5は張架部材2（例えば2a）の回転軸に同軸且つ自由回転可能に設けられるため、自由回転体5の設置スペースを独自に確保する必要性はない。

これにより、従来のような余計な補助張架ブーリを支持するための部材や、スペースを必要とすることなく、被駆動体が連結される張架部材2（例えば2b, 2c）に対する平ベルト1の巻き付け角度を充分に大きく設定することが可能になる。

【0040】

このような技術的手段において、平ベルト1は単数に限定されるものではなく複数でもよいし、また、張架部材2にはブーリ、ロール等を広く含む。

ここで、「駆動力が伝達せしめられる張架部材2（例えば2a）」とは、駆動源に直結されていてもよいし、あるいは、別の駆動伝達系にて駆動されるものでもよい。

更に、「自由回転体5」は、駆動力が伝達せしめられる張架部材2（例えば2a）の回転軸に対して同軸で且つ自由回転可能であることを要し、ペアリング、

カラーなどを広く含む。

【0041】

また、図3の態様では、平ベルト1は通常のものをも含むが、平ベルト1と張架部材2との間の滑りを有効に回避するという観点からすれば、平ベルト1の少なくとも一つには進行方向に沿って一若しくは複数列の貫通孔（図示せず）を設け、当該平ベルト1が掛け渡される張架部材2の少なくとも一つには平ベルト1の貫通孔が嵌合する突起（図示せず）を設ける態様が好ましい。

このような態様によれば、平ベルト1の張架部材2への巻き付け角度を大きくできることから、突起が嵌合する貫通孔部へ作用する力を分散でき、貫通孔部の破壊を有効に防止することができる。

【0042】

更に、自由回転体5が張架部材2の回転軸方向に移動すると、この自由回転体5に掛け渡された平ベルト1が蛇行することになるため、平ベルト1の蛇行を有効に防止するという観点からすれば、自由回転体5の軸方向位置を規制することが好ましい。

この場合、自由回転体5は張架部材2の回転軸の軸方向に対し位置規制部材（図示せず）にて位置規制されるようになっていればよい。

更にまた、自由回転体5自体を軸方向に位置規制したとしても、自由回転体5に掛け渡される平ベルト1自体が蛇行する懸念があるが、これを有効に防止するという観点からすれば、自由回転体5は、掛け渡される平ベルト1の進行方向に直交する幅方向に対する位置を規制する位置規制部を具備していることが好ましい。

ここでいう「位置規制部」には、平ベルト1が孔付きであればその貫通孔に嵌合する突起や、平ベルト1の蛇行を防止する規制壁など広く含む。

【0043】

更に、上述した駆動力伝達装置に係る発明を画像形成装置に適用すると、以下のようになる。

すなわち、本発明に係る画像形成装置は、駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる像担持体と、駆動源からの駆動力を

像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、駆動力伝達装置には、図3に示すように、駆動源と像担持体との間に配設される複数の張架部材2（例えば2a～2c）と、この複数の張架部材2に掛け渡される一若しくは複数の無端状平ベルト1とを備え、駆動力が伝達せしめられる張架部材2の少なくとも一つ（例えば2a）に当該張架部材2aの回転軸に対して同軸で且つ自由回転可能な自由回転体5を設け、この自由回転体5が設けられた張架部材2aとは異なって隣接し合う張架部材2（例えば2b, 2c）に対し平ベルト1を前記自由回転体5を介して掛け渡すようにしたものである。

【0044】

このような画像形成装置によれば、図3に示す駆動力伝達装置は、レイアウトスペースを不必要に拡大することなく、複数の張架部材2への平ベルト1の巻き付け角度を大きく確保でき、駆動力の伝達誤差を低減できるため、小型化、低コストの要請を見たしながら、画像形成装置として出力画像に色ずれや転写ムラなどの画像欠陥が発生するのを防止することができ、安定した画像形成動作を行わせることが可能となる。

更に、省エネルギーやコスト軽減の観点から、像担持体のみならず、転写ロール、帶電ロールなどの像担持体と接触して従動回転する回転体をも含めて单一の駆動源で回転駆動させる場合や、これらの像担持体や他の回転体の軸受が部品点数軽減のためにペアリング等の転がり軸受ではなくすべり軸受が採用される場合に、像担持体の回転負荷は増大する傾向にある。従って、このような画像形成装置に本発明を適用することが好ましい。

【0045】

また、画像形成装置の中には複数系統の像担持体を備えるものが存在するが、図1に示す駆動力伝達装置を組み込んだ画像形成装置と同様に、回転負荷の大きい系統の像担持体に本発明を適用することが好ましい。

このような場合、本発明は、駆動力を発生する駆動源と、駆動源からの駆動力によって回転駆動せしめられる複数系統の像担持体と、駆動源からの駆動力を複数系統の像担持体に伝達する駆動力伝達装置とを備えた画像形成装置において、複数系統の像担持体のうち回転負荷の最も大きい系統の像担持体へ駆動力を伝達

する駆動力伝達装置として、図3に示す駆動力伝達装置を用いるようにすればよい。

更に、単一の駆動源により二系統の像担持体を回転駆動させる場合には、本発明は、二系統の像担持体を備えた画像形成装置において、駆動力伝達装置としては、一の駆動源から第一系統の像担持体へ駆動力を伝達する第一平ベルトと、一の駆動源から第二系統の像担持体へ駆動力を伝達する第二平ベルトとを備えるようにすればよい。

【0046】

また、これらの駆動力伝達装置又は画像形成装置において、平ベルト1の構成は通常一枚のベルト材で構成されることが多いが、張架部材2への掛け渡しを容易にし、かつ、各貫通孔(3, 3a, 3b)部での破壊をより確実に防止するという観点からすれば、平ベルト1の少なくとも一つは、同一材料又は略同一な材料特性を有する複数のベルト材を、少なくとも一部が固定され且つ相互に独立伸縮可能に重合配置したものが好ましい。

すなわち、本態様の平ベルト1は、複数本の同一材料または略同一な材料特性(具体的には、引っ張り強さ、曲げ強さ)を有するベルト材を重ね合わせて張架部材2や自由回転体5に巻きかけられる。

このとき、複数のベルト材を重ね合わせたとしても、当該平ベルト1の曲げ剛性は一枚のベルト材と曲げ剛性と大差なく小さいものが得られるため、当該平ベルト1は張架部材2や自由回転体5に対して安定的に巻き付けられる。

【0047】

また、同一な材料又は略同一な材料特性を有するベルト材を重ね合わせて使用することにより、平ベルト1の貫通孔(3, 3a, 3b)部へ作用する力に対する剛性が上がり、また、平ベルト1を巻き付けた張架部材2に負荷トルクが発生する場合などでも、ベルト張力の変化に対し、複数本のベルト材が略同一に変形するため、1本の平ベルトの貫通孔部へ集中して作用力が働くことがなくなり、貫通孔部の破損を有效地に防止することができ、その分、安定な駆動を実現することができる。

更に、本態様では、平ベルト1は各貫通孔3, 3a, 3bを備えているため、

重合配置されたベルト材相互を位置決めすることが好ましい。

この場合、ベルト材は少なくとも一部が固定されていることが必要になるが、ベルト材の固定法としては、ベルト材の一部を溶接又は接着することにより、各ベルト材の初期位置合わせ(ベルト進行方向、ならびに、直交する方向に対する位置)をすることなく、常に確実なベルト材の重ね合わせを行うことができる。

【0048】

【発明の実施の形態】

以下、添付図面に示す実施の形態に基づいて本発明を詳細に説明する。

◎実施の形態1

図4は、本発明を適用した複写機(画像形成装置)80の実施の形態1を示す断面概略図である。

同図において、この複写機80の構成を、画像入力系、画像形成系、シート搬送系に分けてそれぞれ説明する。

画像入力系は、原稿が載置される原稿載置台70、この原稿載置台70上の原稿を読み取る原稿読取装置71、この原稿読取装置71にて読み取られた画像情報を処理する画像処理装置72を備えている。

画像形成系は、ブラック、イエロ、マゼンタ、シアンの各色に対応する画像形成ステーション10(具体的には10K, 10Y, 10M, 10C:図中点線で囲む部分)、この画像形成ステーション10に画像処理装置72からの画像データに基づいて露光する露光装置13(具体的には13K~13C)、各画像形成ステーション10にて形成された画像が順次転写保持せしめられる二つの第一中間転写ドラム31(具体的には31a, 31b)、及び、一つの第二中間転写ドラム32を備えている。

【0049】

ここで、各画像形成ステーション10には、感光体ドラム11(具体的には11K~11C)、感光体ドラム11を帶電する帶電装置12(具体的には12K~12C)、帶電された感光体ドラム11上に露光装置13により書き込まれた静電潜像を各色トナーにて現像する現像装置14(具体的には14K~14C)などの電子写真用デバイスが具備されている。

尚、各感光体ドラム11(11K~11C)と第一中間転写ドラム31a, 31bとが対峙する部分には図示しない(一次)転写装置が、第一中間転写ドラム31a, 31bと第二中間転写ドラム32とが対峙する部分には図示しない(二次)転写装置が夫々設けられている。

【0050】

更に、シート搬送系は、用紙等の記録シートが積載されるシートトレイ40、シートトレイ40内の記録シートを一枚ずつ繰り出すピックアップロール41、繰り出された記録シートを位置決めするレジストロール42、第二中間転写ドラム32上の画像を記録シートに転写する(三次)転写ロール43、記録シート上に転写された画像を定着する定着ロール44、排出された記録シートを収容する排出トレイ45などを備えている。

【0051】

次に、このような複写機80の基本的なフルカラー複写動作について説明する

まず、ユーザが原稿載置台70の上に読み取原稿を載せ、図示しないユーザインターフェイスにより複写指示を行うと、画像読み取り装置71が走査しつつ原稿を光学的に読み取り、電気信号(画像データI)に変換する。その画像データIは、画像処理装置72において、ブラック、イエロ、マゼンタ、シアンの各色に色分解され、それら各色の画像データI(IK, IY, IM, IC)に、マーキングデバイス/プロセスの特性を考慮した所定の重み係数を付与する等の画像処理が施される。

【0052】

一方、各画像形成ステーション10内の感光体ドラム11は、後述するベルト駆動装置100(図5、図6参照)により図中矢印の方向へ回転駆動されている。この感光体ドラム11の表面は、帯電装置12により一様な所定電位に帯電される。そして、各露光装置13(13K~13C)がそれぞれ画像データI(IK~IC)に対応した露光光を所定タイミングで各感光体ドラム11(11K~11C)表面に照射することにより、各感光体ドラム11(11K~11C)表面には電位差による静電潜像が形成される。その静電潜像は、各現像装置14(

14K～14C)によりトナーが静電的に付着され、トナー画像T(K, Y, M, C)となる。

【0053】

他方、第一中間転写ドラム31a, 31b及び第二中間転写ドラム32は、後述するベルト駆動装置100(図5、図6参照)により図中矢印の方向へ回転駆動されている。そして、このトナー画像T(K, Y)は、図示しない一次転写装置により感光体ドラム11(11K, 11Y)から第一中間転写ドラム31aへ、トナー画像T(M, C)は、感光体ドラム11(11M, 11C)から第一中間転写体ドラム31bへと静電的に(一次)転写される。この際、トナー画像T(K, Y)は第一中間転写ドラム31a表面で重ね合わされ、トナー画像T(M, C)は第一中間転写ドラム31b表面で重ね合わされる。

【0054】

更に、第一中間転写ドラム31a上で重ね合わされたトナー画像T(KY)は、図示しない二次転写装置により第二中間転写ドラム32へ、同じく第一中間転写ドラム31b上で重ね合わされたトナー画像T(MC)も第二中間転写ドラム32へと静電的に(二次)転写される。この際、トナー画像T(KY)とトナー画像T(MC)とは第二中間転写ドラム32表面で重ね合わされ、フルカラーのトナー画像T(KYMC)が形成される。

このように、トナー画像T(KYMC)が形成される間、シート搬送系においては、シートトレイ40内の記録シートSがピックアップロール41により一枚取り出され、レジストロール42へと搬送される。例えばレジストロール42が停止状態から所定タイミングまで回転を開始することにより、第二中間転写ドラム32上のフルカラートナー画像T(KYMC)が転写ロール43とのニップ部に達するタイミングと、記録シートSがそのニップ部分に達するタイミングとを一致させ、転写ロール43により第二中間転写ドラム32上のフルカラートナー画像T(KYMC)が記録シートSに静電的に転写される。

その後、表面にフルカラートナー画像T(KYMC)を静電的に保持する記録シートSは、定着ロール44のニップ部分を通過する際に、各定着ロール44からの熱と圧力とその作用によりそのフルカラートナー画像T(KYMC)を表面

に定着させ、複写機80外部の排出トレイ45へと排出される。

このような複写工程を一サイクルとし、これを連続的に行うことにより、次々にフルカラー画像を複写することができる。

【0055】

図5は、この複写機80を駆動するベルト駆動装置100を示す斜視図であり、図4の背面側から眺めた構成を示すものである。尚、図6(a)は図5のベルト駆動装置100の正面説明図、(b)はその平面説明図である。

同図において、ベルト駆動装置100は、各感光体ドラム11(11K~11C)、第一中間転写ドラム31a, 31b、及び、第二中間転写ドラム32を駆動するものであり、二つの平ベルト101, 102と、これらの平ベルト101, 102が張架せしめられる各種張架部材とを備えている。

ここで、張架部材としては、各感光体ドラム11(11K~11C)、第一中間転写ドラム31a, 31b、及び、第二中間転写ドラム32のそれぞれ軸方向一端に取り付けられた従動ブーリ111~117と、各平ベルト101, 102の取り回しを行うための張架ブーリ121, 122とがある。

尚、本実施の形態では、第二中間転写ドラム32に取り付けられた従動ブーリ117は第一、第二の平ベルト101, 102がそれぞれ掛け渡される二段のベルト掛け渡し面を有している。

【0056】

そして、第一の平ベルト101は、張架ブーリ121と、各感光体ドラム11(11K~11C)の軸に取り付けられた従動ブーリ111~114と、第二中間転写体ドラム32の軸に取り付けた従動ブーリ117とに掛け渡されている。

一方、第二の平ベルト102は、張架ブーリ122と、第一中間転写ドラム31a, 31bの軸に取り付けた従動ブーリ115, 116と、第二中間転写体ドラム32の軸に取り付けた従動ブーリ117とに掛け渡されている。

尚、各ブーリ111~117, 121, 122に設けられているブーリ軸(図示せず)は、複写機80の側面に設けられる各すべり軸受により軸受され、各ブーリは回転自在に構成されている。

【0057】

ここで、図示外の駆動モータ（駆動源）からの出力をどの軸に与えるかであるが、平ベルトとブーリの巻き付け角度が大きいブーリ軸に駆動モータからの駆動を入力させる構成をとることが望ましい。

本実施の形態においては、例えば第二中間転写ドラム32の軸へ駆動モータからの駆動力を入力するように設定することができるが、他のブーリ軸へ駆動モータからの駆動力を入力する構成としてもよい。

また、平ベルト101, 102の材質としては樹脂製のものを採用することもできるが、耐久性や加工精度等の面からステンレス、ニッケル、チタン等の金属を使用することが好ましく、価格、耐久性、機械的強度の観点からステンレスを使用することが特に好ましい。

同様に、各ブーリの材質としては樹脂製のものを採用することもできるが、耐久性や加工精度等の面からステンレス、アルミニウム、炭素鋼等の金属を使用することが好ましい。特に、金属製のブーリは樹脂製のブーリに比べて一般的に慣性モーメントが大きくなるため、画像形成装置において出力画像の画像欠陥を招くとして問題視されている噛み合い振動などの高周波振動の減衰効果が期待でき、その観点からもブーリの材質としては金属が好ましい。また、金属のうちでは価格、耐久性、機械的強度の観点からステンレスを使用することが特に好ましい。

【0058】

図7は、平ベルトとブーリとの構成をより詳細に説明するものである。

ここでは、図4の中間転写ドラム駆動に用いる平ベルト101, 102、及び、各ブーリ110(111～117, 121, 122)を例に挙げて説明する。

図4に示した第一中間転写ドラム31a, 31bは、図示外のクリーナが当接しており、他のドラムと比較して大きな負荷が与えられている。そのため、本実施の形態では、第一、第二の平ベルト101, 102には、進行方向に沿って複数列（本例では3列）の貫通孔130が設けられ、また、各ブーリ110の全部若しくは一部（本例では全部の例が示されている）には平ベルト101, 102の貫通孔130に対応して複数列（本例では3列）の突起140が設けられており、平ベルト101, 102の貫通孔130にブーリ110の突起140を嵌合

させることで、平ベルト101, 102の安定な駆動が実現されるようになっている。

本実施の形態で、貫通孔130としては例えば円形孔が用いられ、一方、突起140としては半球状突起が用いられる。

【0059】

図7(a) (b) (c)に示す本実施の形態において、平ベルト101, 102の全ての列の貫通孔130ピッチは同一間隔に設定されているが、特に合わせる必要はなく、各列にて間隔を変更することも可能である。また、3列の貫通孔130のうち、中央列の貫通孔130bピッチ p は、両側列の貫通孔130a, 130cピッチ p と同一間隔であるが、位相 θ を180度ずらして設定されている。

これは、後述するように、ベルト蛇行による貫通孔部の破壊を防止する目的で故意に変えているものである。

また、本実施の形態において、平ベルト101, 102には複数列の貫通孔130が設けられているが、プーリ110に設ける突起140は前記貫通孔130に対応して複数列設けられているが、必ずしも全ての貫通孔130に対応させて設ける必要はなく、少なくとも負荷の最も大きいプーリ110に設けるようにすればよい。

このため、負荷が小さいプーリ110には、複数列全てに嵌合させる必要はなく、3列中の1列を嵌合するようにすることも可能であるし、突起140のピッチを貫通穴ピッチの整数倍とすることも可能である。よって、複数列の貫通孔130を設けた平ベルト101, 102と、この平ベルト101, 102が巻き付く幾つかのプーリ110の各々の嵌合仕様は、使用するケース毎に自由に設計することができる。

【0060】

図8(a), (b)は、本実施の形態における構成の負荷に対する効果の概要を、図8(c), (d)はベルト蛇行に対する効果の概要をそれより詳細に説明するものである。

図8は矢印A方向に循環移動するパーフォレーションベルト（貫通孔付き平ベ

ルト)と、このベルトに設けた貫通孔と嵌合するブーリに設けた突起とを表している。

図8(a)は、貫通孔130'が1列孔タイプの比較の態様(平ベルト101', 102')における駆動状態を示しており、高負荷の場合には、図示するように貫通孔130'部の循環方向と反対側で駆動を行うことになり、突起140'と噛み合う部分に歪みが生じる。この歪みがある大きさ以上になるとベルトの貫通孔130'部は破壊され、駆動が不安定になる。

この歪みの影響を低減し、安定な駆動を行わせるため、本実施の形態では、図8(b)に示すような循環方向に対し、平ベルト101, 102に複数列の貫通孔130を設けた構成としている。これにより、高負荷のブーリ110を駆動する際に生じる1個あたりの貫通孔130部の歪みを低減し、安定な駆動伝達を行うことが可能となる。

【0061】

図8(c)は、本実施の形態において、平ベルト101, 102の複数列の貫通孔130を同位相で配列した変形形態を示す。

この場合、負荷に対する効果は、図8(b)と同様で、貫通孔130部の1個当たりの歪みを低減することが可能である。しかし、ベルト蛇行が発生するような状況では、蛇行方向に対する貫通孔130部のピッチが細かくなりすぎるため、歪みを吸収する領域がなくなり、貫通孔130部の破壊を招きやすい。

そのため、ベルト蛇行方向を考える場合には、本実施の形態のように、図8(d)のような構成とすることが望ましい。

このため、ベルト幅が十分広く取れる場合では、複数列設けた蛇行方向の貫通孔ピッチも大きくとれるため、図8(c)の構成でも問題はないが、画像形成装置などの小型化が要求される場合には、図8(d)の構成を取る方が望ましい。よって、本実施の形態では、図8(b), (d)の構成をとることにより、安定な駆動を実現することが可能となる。

【0062】

従って、本実施の形態によれば、平ベルト101, 102の貫通孔130部で破壊が起こる懸念はなく、駆動モータからの駆動力が感光体ドラム11(11K

～11C)、第一中間転写ドラム31a, 31b、及び、第二中間転写ドラム32に確実に伝達される。

このことは、後述する実施例1にて裏付けられる。

【0063】

特に、現在、銳意開発が進められているカラー画像形成装置の分野では、消費電力やコスト低減の必要性から、感光体ドラムのみならず中間転写ドラムや中間転写ベルト、さらには転写ロールや帶電ロールまで単一の駆動モータで駆動する方式が追求されており、画像形成動作を実施するために駆動力伝達部材が打ち勝たなければならぬ負荷トルクは次第に増大する傾向にある。

更に、部品コスト削減のために、各像担持体ドラムの回転軸を支持する軸受が、従来から使用されていた転がり軸受から、すべり軸受に変更されるケースが多く、この軸受の変更によっても負荷トルクの増大に拍車がかかっているという状況にある。

このような要請下においても、本実施の形態は極めて有効である。このことは、以後の実施の形態においても同様である。

【0064】

尚、本実施の形態では、ベルト駆動装置100としては、二つの平ベルト101, 102と、これらを掛け渡すブーリ110(111～117, 121, 122)とからなるものが用いられているが、これに限られるものではなく、例えば図9に示すように、一つの平ベルト103と、これを掛け渡すブーリ(従動ブーリ111～117, 張架ブーリ121)とを備え、例えば第二中間転写ドラム32に連結される従動ブーリに駆動モータからの駆動力を入力し、各ブーリ110に掛け渡された一つの平ベルト103を介して各ブーリ110に駆動力を伝達し、感光体ドラム11(11K～11C)、第一中間転写ドラム31a, 31b、第二中間転写ドラム32を駆動するようにしてもよい。

【0065】

◎実施の形態2

図10は、本発明を適用した実施の形態2に係る複写機(画像形成装置)90の断面概略図である。

同図において、この複写機90の構成を、画像入力系、画像形成系、シート搬送系に分けてそれぞれ説明する。

画像入力系は、原稿載置台70、原稿読取装置71、画像処理装置72を備えている。

また、画像形成系は、ブラック、イエロ、マゼンタ、シアンの各色に対応する画像形成ステーション10（具体的には10K, 10Y, 10M, 10C：図中点線で囲む部分）、及び、この画像形成ステーション10に画像処理装置72からの画像データに基づいて露光する露光装置13（具体的には13K～13C）を備えている。

ここで、画像形成ステーション10（10K～10C）には、感光体ドラム11（具体的には11K～11C）、感光体ドラム11を帯電する帯電装置12（具体的には12K～12C）、帯電された感光体ドラム11上に露光装置13にて書き込まれた静電潜像を各色トナーにて現像する現像装置14（具体的には14K～14C）、感光体ドラム11上の残留トナーを清掃するドラムクリーナ15（具体的には15K～15C）、及び、感光体ドラム11上の画像を記録シートSに転写する転写ロール22（具体的には22K～22C）などの電子写真用デバイスが具備されている。

特に、本実施の形態では、感光体ドラム11（11K～11C）は各ベルト駆動装置50（具体的には50K～50C）により駆動されるようになっているが、各ベルト駆動装置50（50K～50C）は単一の駆動モータからの駆動力を図示外の全体ベルト駆動装置を介して各ベルト駆動装置50の駆動力伝達軸に取り込むようになっている。

【0066】

更に、シート搬送系は、レジストロール42の後段に、各画像形成ステーション10（10K～10C）に対応して記録シートSを搬送するシート搬送ベルト20を有し、このシート搬送ベルト20の後段に定着ロール44などを備えている。

そして、本実施の形態では、シート搬送ベルト20は、少なくとも駆動ロール24aが含まれる複数の張架ロール24（24a～24e）に掛け渡されており

、このシート搬送ベルト20の周囲には、ベルトクリーナ26、ベルト除電装置27、シート搬送ベルト20に記録シートSを吸着保持するための吸着用帯電装置28、及び、シート搬送ベルト20から記録シートSを剥離するための剥離用帯電装置29が設けられている。

【0067】

次に、このような複写機90の基本的なフルカラー複写動作について説明する。

まず、ユーザが原稿載置台70の上に読み取り原稿を載せ、図示しないユーザインターフェイスにより複写指示を行うと、画像読取装置71が走査しつつ原稿を光学的に読み取り、電気信号（画像データI）に変換する。その画像データIは、画像処理装置72において、ブラック、イエロ、マゼンタ、シアンの各色に色分解され、それら各色の画像データI（IK, IY, IM, IC）に、マーキングデバイス／プロセスの特性を考慮した所定の重み係数を付与する等の画像処理が施される。

【0068】

一方、各画像形成ステーション10内の感光体ドラム11は、ベルト駆動装置50（50K～50C）により図中矢印の方向へ回転駆動されている。この感光体ドラム11（11K～11C）の表面は、帯電装置12（12K～12C）により一様な所定電位に帯電される。そして、各露光装置13（13K～13C）がそれぞれ画像データI（IK～IC）に対応した露光光を所定タイミングで各感光体ドラム11（11K～11C）表面に照射することにより、各感光体ドラム11表面には電位差による静電潜像が形成される。その静電潜像は、各現像装置14（14K～14C）によりトナーが静電的に付着され、トナー画像T（K, Y, M, C）となる。

【0069】

このように、トナー画像T（K, Y, M, C）が形成される間、シート搬送系においては、図示外のシートトレイ内の記録シートSが図示外のピックアップロールにより一枚取り出され、レジストロール42へと搬送される。例えばレジストロール42が停止状態から所定タイミングで回転を開始することにより、図示

外の駆動装置により図中矢印の方向へ回転駆動されているシート搬送ベルト20へ記録シートSが引き渡される。

尚、レジストロール42からシート搬送ベルト20へと記録シートSが引き渡される際に、吸着用帯電装置28により記録シートSへシート搬送ベルト20に吸着するような電荷が与えられる。

【0070】

そして、この感光体ドラム11(11K~11C)上のトナー画像T(K, Y, M, C)は、転写ロール22(22K~22C)により各感光体ドラム11(11K~11C)からシート搬送ベルト20上の記録シートSへと順次静電的に転写される。この際、記録シートSにはまずトナー画像T(K)が一次転写され、トナー画像T(K)の上にトナー画像T(Y)が、その上にトナー画像T(M)が、更にその上にトナー画像T(C)が順に重ね合わされ、結果としてフルカラーのトナー画像T(K, Y, M, C)が形成される。

尚、一次転写後に各感光体ドラム11(11K~11C)表面に残存する一部のトナーなどの異物は、ドラムクリーナ15(15K~15C)により除去される。また、シート搬送ベルト20表面に残存するトナーなどの異物は、ベルトクリーナ26により除去される。更に、シート搬送ベルト20に残存する電位履歴は、ベルト除電装置27により除去される。

【0071】

その後、表面にフルカラートナー画像T(K, Y, M, C)を静電的に保持する記録シートSは、定着ロール44のニップ部分を通過する際に、各定着ロール44からの熱と圧力との作用によりそのフルカラートナー画像T(K, Y, M, C)を表面に定着させ、複写機90外部へと排出される。

ここで、シート搬送ベルト20から定着ロール44へと記録シートSが引き渡される際に、剥離用帯電装置29により記録シートSへシート搬送ベルト20から剥がれるような電荷が与えられる。

このような複写工程を一サイクルとし、これを連続的に行うことにより、次々にフルカラー画像を複写することができる。

【0072】

このような複写機90の各感光体ドラム11(11K~11C)の駆動に使用される各ベルト駆動装置50(50K~50C)及び全体ベルト駆動装置について、実施の形態1のように、複数列の孔付き平ベルトと突起付きブーリとを適用するようすれば、実施の形態1と同様な作用、効果を奏することができる。

また、シート搬送ベルト20の駆動装置についても、実施の形態1と同様なベルト駆動装置を適用することもでき、その両方の駆動に実施の形態1と同様なベルト駆動装置を適用するようにしてもよい。

【0073】

◎実施の形態3

実施の形態1、2はいずれも画像形成装置に適用されるベルト駆動装置を示したものであるが、本実施の形態は、広く被駆動体を駆動するベルト駆動装置の代表的な態様を示す。

図11(a)~(d)に係るベルト駆動装置100は、一つの平ベルト105と、この平ベルト105が掛け渡される張架部材とを備え、張架部材としては、いずれも駆動モータ(図示せず)からの駆動力が伝達される駆動ブーリ151と、この駆動ブーリ151に隣接して設けられ且つ被駆動体(図示せず)が連結される例えば二つの従動ブーリ152、153と、平ベルト105を取り回すための張架ブーリ154とを備えている。

【0074】

本実施の形態において、平ベルト105には、平ベルト105の進行方向に沿って複数列(本例では3列)の貫通孔130を実施の形態1のように開設され、ブーリ151~154の全部若しくは一部(本例では、例えば駆動ブーリ151、従動ブーリ152、153)には前記貫通孔130に対応して複数列の突起140が設けられ、平ベルト105の貫通孔130にブーリ151~153の突起140を嵌合させることで、平ベルト105の安定な駆動が実現されるようになっている。

この態様によれば、実施の形態1と同様に、被駆動体が連結された従動ブーリ152、153に大きな負荷が作用したり、平ベルト105が蛇行しようとしても、平ベルト105の貫通孔130部への作用力を分散させながら被駆動体へ確

実際に駆動力を伝達することができる。

【0075】

また、図11（b）に係るベルト駆動装置100は、3列の貫通孔タイプでベルト蛇行方向（進行方向に対し直交する幅方向）に各列の貫通孔131が重複しないように斜めに配列させ、かつ、ブーリ151～154の全部あるいは一部には前記貫通孔131に対応した突起141を設けたものであり、図11（a）よりもベルト幅方向に対する剛性を強化することが可能である。

更に、図11（c）に係るベルト駆動装置100は、2列の貫通孔タイプでベルト蛇行方向（進行方向に対し直交する幅方向）に各列の貫通孔132を重複しないように斜めに配列させ、かつ、ブーリ151～154の全部あるいは一部には前記貫通孔132に対応した突起142を設けたものである。

【0076】

更にまた、図11（d）に係るベルト駆動装置100は、2列の貫通孔タイプでベルト蛇行方向（進行方向に対し直交する幅方向）に各列の貫通孔133を並べて配列させ、かつ、ブーリ151～154の全部あるいは一部には前記貫通孔133に対応した突起143を設けたものである。

この図11（d）の態様にあっては、ベルト蛇行が大きく発生する場合には好ましくないが、従動ブーリ152、153へ負荷がかかったときに2列の貫通孔133が同時に噛み合い駆動するため、高負荷を駆動する時には有効な配列である。

よって、適用する駆動仕様に応じ、本実施の形態のような幾つかの構成を組み合わせることにより、安定な駆動を行い、かつ、高度な回転ムラ精度を達成することが可能となる。

【0077】

◎実施の形態4

図12は本発明が適用されたベルト駆動装置の実施の形態4を示す。

同図において、ベルト駆動装置100は、実施の形態3と略同様に、一つの平ベルト105と、この平ベルト105が掛け渡される張架部材（駆動ブーリ151、従動ブーリ152、153、張架ブーリ154）とを備えているが、実施の

形態3と異なり、平ベルト105には、平ベルト105の進行方向に直交する幅方向に延びる長孔状貫通孔301が図示のように開設され、各ブーリ151～154全部若しくは一部（本例ではブーリ151～153）には前記長孔状貫通孔301に対応して略半円柱形状の柱状突起302が設けられ、平ベルト105の長孔状貫通孔301に各ブーリ151～154の柱状突起302を嵌合させることで、平ベルト105の安定な駆動が実現されるようになっている。

【0078】

次に、本実施の形態で用いられるブーリ151～153及び平ベルト105の詳細を示す。

本実施の形態において、ブーリ151～153は、図13（a）に示すように、周面に略半円柱形状の柱状突起302を備えているが、これらのブーリ151～153は、例えば図13（c）に示すように、ブーリ本体311の周面に半円柱形状のピン係合溝312を適宜間隔で形成し、この各ピン係合溝312に円柱ピン313をブーリ本体311の径方向外側から圧入することで柱状突起302を形成し、このブーリ本体311を2枚の押さえ円板314、315にて挟み込み、ネジ等の止め具316で固定するようにしたものである。

また、平ベルト105は、図13（b）に示すように、長孔状貫通孔301を備えているが、この長孔状貫通孔301は、例えばSUS材からなる平ベルト105を長孔形状にエッティング加工することで実現可能であり、これ以外にプレス加工や放電加工により実現するようにしてもよい。

尚、長孔状貫通孔301と柱状突起302との関係については、両者の嵌合性を良好に保つという観点からすれば、長孔状貫通孔301を柱状突起302に比べて僅かに大きく設定することが好ましい。そして、両者の嵌合性をより良好に保つには、長孔状貫通孔301の長手方向両端部を円弧状に形成する一方、前記柱状突起302の長手方向両端部をも滑らかな曲面部形状とすることが好ましい

【0079】

従って、本実施の形態によれば、図14に示すように、例えば被駆動体が連結された従動ブーリ152、153に大きな負荷が作用しても、平ベルト105の

長孔状貫通孔301部への作用力を直線部301aで受けながら被駆動体へ確実に駆動力を伝達することができる。

それゆえ、本実施の形態のような構成をとることにより、安定な駆動を行い、かつ、高度な回転ムラ精度を達成することが可能となる。

【0080】

◎実施の形態5

図15は本発明が適用されたベルト駆動装置の実施の形態5の要部を示す。

図15に示すように、本実施の形態では、平ベルト105には、平ベルト105の進行方向に直交する方向に延びる長孔状貫通孔321及び円形貫通孔322が図示のように交互に所定ピッチ間隔で開設され、プーリ151～154全部若しくは一部には前記貫通孔321, 322に対応して略半円柱形状の柱状突起323及び略半球状突起324が設けられ、平ベルト105の各貫通孔321, 322にプーリ151～154の各突起323, 324を嵌合させることで、平ベルト105の安定な駆動が実現されるようになっている。

【0081】

例えば実施の形態4では、図13(c)に示す方法にてプーリ151～154を製作すると、柱状突起302は、2枚の押さえ円板314, 315で挟み込まれるため、挟まれる中央のプーリ本体311幅より、柱状突起302になるべき円柱ピン313は短いものを使用することが好ましい。

しかし、製作された半円柱形状の柱状突起302がプーリ151～154の軸方向の位置に対しばらつきを有すると、平ベルト105が蛇行した場合に、最悪長孔状貫通孔301が一つで平ベルト105の蛇行を規制することになり、この長孔状貫通孔301には大きな作用力が生じる懸念がある。

そこで、本実施の形態では、図15に示すように、柱状突起323と長孔状貫通孔321の平ベルト105の進行方向における縁部との隙間をd1、柱状突起323と長孔状貫通孔321の平ベルト105の幅方向における縁部との隙間をd2、略半球状突起324と円形貫通孔322の平ベルト105の幅方向における縁部との隙間をd3とすれば、 $d1 \leq d3 \leq d2$ の関係を満たすように設定されている。

【0082】

このような寸法関係に設定すれば、略半球状突起324と平ベルト105の円形貫通孔322とで平ベルト105の蛇行を規制し、負荷トルクによる作用力に対しては、半円柱形状の柱状突起323と平ベルト105の長孔状貫通孔321とで作用力を分散させた状態で駆動搬送する、機能分離型のベルト駆動装置が実現できる。

よって、実施の形態4と同様に、被駆動体が連結された従動プーリ152、153に大きな負荷が作用し、かつ、平ベルト105が蛇行しようとしても、平ベルト105の貫通孔（長孔状貫通孔321、円形貫通孔322）部への作用力（負荷による進行方向の力と平ベルト105蛇行による進行方向と略直交する方向の力）を分散させながら、被駆動体へ確実に駆動力を伝達することができる。

【0083】

◎実施の形態6

図16は本発明が適用されたベルト駆動装置の実施の形態6を示す。

同図において、本実施の形態に係るベルト駆動装置は、実施の形態5と略同様に構成されるが、実施の形態5と異なり、平ベルト105には、平ベルト105の進行方向に直交する方向に延びる長孔状貫通孔321が図示のように所定ピッチ間隔で開設され、プーリ151～154全部若しくは一部には前記長孔状貫通孔321に対応して略半円柱形状の柱状突起323及び対構成の略半球状突起325が交互に所定ピッチ間隔（本例では長孔状貫通孔321のピッチ間隔の2倍に設定）で設けられ、平ベルト105の各貫通孔321にプーリ151～154の各突起323、325を嵌合させることで、平ベルト105の安定な駆動が実現されるようになっている。

【0084】

本実施の形態では、図16（a）に示すように、柱状突起323と長孔状貫通孔321の平ベルト105の進行方向における縁部との隙間をd1、柱状突起323と長孔状貫通孔321の平ベルト105の幅方向における縁部との隙間をd2、略半球状突起325と長孔状貫通孔321の平ベルト105の幅方向における縁部との隙間をd3とすれば、 $d1 \leq d3 \leq d2$ の関係を満たすように設定さ

れている。

【0085】

このような寸法関係に設定すれば、図16(b)に示すように、略半球状突起325と平ベルト105の長孔状貫通孔321とで平ベルト105の蛇行を規制し、負荷トルクによる作用力に対しては、半円柱形状の柱状突起323と平ベルト105の長孔状貫通孔321とで作用力を分散させた状態で駆動搬送する、機能分離型のベルト駆動装置が実現できる。

よって、実施の形態においても、被駆動体が連結された従動プーリ152、153に大きな負荷が作用し、かつ、平ベルト105が蛇行しようとしても、平ベルト105の長孔状貫通孔321部への作用力(負荷による進行方向の力と平ベルト105蛇行による進行方向と略直交する方向の力)を分散させながら、被駆動体へ確実に駆動力を伝達することができる。

【0086】

特に、本実施の形態では、平ベルト105には長孔状貫通孔321を所定ピッチ間隔で形成するようにしているので、プーリ側に形成する各種突起のパターンに自由度を与えることができる。

例えば長孔状貫通孔321の配列ピッチ間隔毎に柱状突起302(323)を形成してもよいし、長孔状貫通孔321の配列ピッチの2倍の間隔で柱状突起323及び対構成の略半球状突起325を形成するようにしてもよいし、長孔状貫通孔321に対して柱状突起323及び対構成の略半球状突起325を2:1の割合で形成するなど適宜選定して差し支えない。

【0087】

◎実施の形態7

図17は、本発明が適用された複写機(画像形成装置)80の実施の形態7に適用されるベルト駆動装置の概要を示す。

同図において、複写機80の基本的構成は、実施の形態1と略同様に、四つの感光体ドラム11(11K~11C)と、二つの第一中間転写ドラム31a、31bと、第二中間転写ドラム32とを備えたものであるが、ベルト駆動装置160の構成が実施の形態1と異なる。尚、実施の形態1と同様な構成要素について

は実施の形態1と同様な符号を付してここではその詳細な説明を省略する。

本実施の形態において、ベルト駆動装置160は、図17～図19に示すように、各感光体ドラム11(11K～11C)、第一中間転写ドラム31a、31b、及び、第二中間転写ドラム32を駆動するものであり、二つの平ベルト171、172と、これらの平ベルト171、172が張架せしめられる各種張架部材とを備えている。

ここで、張架部材としては、各感光体ドラム11(11K～11C)、第一中間転写ドラム31a、31b、及び、第二中間転写ドラム32のそれぞれ軸方向一端に取り付けられた従動ブーリ181～187と、各平ベルト171、172の取り回しを行うための張架ブーリ191、192とがある。

尚、本実施の形態では、第二中間転写ドラム32に取り付けられた従動ブーリ187は第一、第二の平ベルト171、172がそれぞれ掛け渡される二段のベルト掛け渡し面を有している。

【0088】

そして、第一の平ベルト171は、張架ブーリ191と、各感光体ドラム11(11K～11C)の軸に取り付けられた従動ブーリ181～184と、第二中間転写体ドラム32の軸に取り付けた従動ブーリ187とに掛け渡されている。

一方、第二の平ベルト102は、張架ブーリ192と、第一中間転写ドラム31a、31bの軸に取り付けた従動ブーリ185、186と、第二中間転写体ドラム32の軸に取り付けた従動ブーリ187とに掛け渡されている。

尚、各ブーリ181～187、191、192に設けられているブーリ軸(図示せず)は、複写機80の側面に設けられる各すべり軸受により軸受され、各ブーリは回転自在に構成されている。また、本例では、従動ブーリ187の二段のベルト掛け渡し面のうち、第一の平ベルト171に対するベルト掛け渡し面が第二の平ベルト172に対するベルト掛け渡し面よりも大径に形成されている。

特に、本実施の形態では、平ベルト171、172は進行方向に沿って例えば一列の貫通孔175を具備し、これらが掛け渡されるブーリの全部若しくは一部には前記貫通孔175に対応した突起176を設け、両者を嵌合させることで、駆動力を伝達するパフォレーションベルトにて構成されている。

【0089】

ここで、図示外の駆動モータ（駆動源）からの出力をどの軸に与えるかであるが、平ベルトとプーリの巻き付け角度が大きいプーリ軸に駆動モータからの駆動を入力させる構成をとることが望ましい。

本実施の形態においては、例えば第二中間転写ドラム32の軸へ駆動モータからの駆動力を入力するように設定することができるが、他のプーリ軸へ駆動モータからの駆動力を入力する構成としてもよい。

また、平ベルトの材質やプーリの材質については、実施の形態1と同様に適宜選定して差し支えなく、例えば平ベルトとしては、耐久性や加工精度等の面からステンレス、ニッケル、チタン等の金属を使用することが好ましい。一方、プーリの材質については、耐久性や加工精度等の面からステンレス、アルミニウム、炭素鋼等の金属を使用することが好ましい。

【0090】

特に、本実施の形態においては、第一中間転写ドラム31a, 31bの従動プーリ185, 186には、同従動プーリ185, 186軸と同軸で且つ自由回転可能な自由回転体200（具体的には200a, 200b）が設けられており、平ベルト171は、感光体ドラム11（11K, 11Y）の従動プーリ181, 182には自由回転体200aを介して掛け渡され、一方、感光体ドラム11（11M, 11C）の従動プーリ183, 184には自由回転体200bを介して掛け渡されている。

ここで、自由回転体200としては、軸に対して自由回転し得る部材であればカラーなどを始め適宜選定して差し支えないが、本例では、例えば図20（a）（b）に示すように、ボールベアリングが用いられる。このボールベアリングは、前記従動プーリ185, 186軸に圧入連結される内輪ケース201と、この内輪ケース201の外側にボール203を介して回転自在に設けられる外輪ケース202とで構成される。

【0091】

また、自由回転体200は、第一中間転写ドラム31a, 31bの回転軸310の軸方向に対して位置を規制することが好ましい。

上記自由回転体200が軸方向に自由度を持つと、平ベルト171, 172の蛇行を発生させる原因となり、例えばパフォレーションベルトのような孔付き平ベルトを使用している場合などでは、自由回転体200の上流側、下流側の感光体ドラム11（本例では11K, 11Y）用の従動プーリ181, 182あるいは感光体ドラム11（本例では11M, 11C）用の従動プーリ183, 184の突起176と平ベルト171, 172の貫通孔175とが擦れ、貫通孔175部の破壊を招き易い。

ここで、自由回転体200の軸方向規制としては、図20（b）に示すように、例えばEリングやOリング等の位置規制部材210を自由回転体200の両側あるいは片側（本例では両側）に設けるようにすればよい。

【0092】

また、本実施の形態において、上記自由回転体200の周面には平ベルト171, 172が掛け渡されているが、図20（b）に仮想線で示すように、自由回転体200の周面（本例では外輪ケース202の周面）に平ベルト171, 172の貫通孔175に対応して突起205を設け、自由回転体200と平ベルト171, 172との間の軸方向に対する位置規制を行うことがより好ましい。

【0093】

次に、本実施の形態に係る画像形成装置のベルト駆動装置の作動について説明する。

本実施の形態において、第二中間転写ドラム32の回転軸に駆動モータからの駆動力が入力されると、第二中間転写ドラム32の従動プーリ187が回転し、第二の平ベルト172、従動プーリ185, 186及び張架プーリ192を介して第一中間転写ドラム31a, 31bに駆動力が伝達される。

一方、第二中間転写ドラム32の従動プーリ187が回転すると、第一の平ベルト171、従動プーリ181～184、張架プーリ192及び自由回転体200（200a, 200b）を介して各感光体ドラム11（11K～11C）に駆動力が伝達される。

【0094】

このとき、第一の平ベルト171は、各感光体ドラム11の隣接し合う従動プ

ーリ181～184に対し自由回転体200a、張架ブーリ191、自由回転体200bを介して約180°以上の巻き付け角度をもって掛け渡されている。

この状況において、第一の平ベルト171と各従動ブーリ181～184との巻き付け領域が増加することから、その分、従動ブーリ181～184への駆動力の伝達が安定するばかりか、第一の平ベルト171の貫通孔175と従動ブーリ181～184の突起176との嵌合による貫通孔175部に作用する力が分散するため、前記貫通孔175部に局部応力が作用することに伴う貫通孔175部の破壊は有效地に回避される。

【0095】

特に、本例では、第一中間転写ドラム31a, 31bの回転軸方向と、自由回転体200の回転方向とは逆方向であるが、自由回転体200は第一中間転写ドラム31a, 31bの回転軸に対して自由回転可能であるため、第一の平ベルト171の移動が損なわれることはない。

仮に、自由回転体200がないとすれば、第一の平ベルト171を直接第一中間転写ドラム31a, 31bの回転軸に巻き付けることになるが、このような態様にあっては、平ベルト171にかかる負荷及び駆動負荷が大きくなり、摩擦による第一の平ベルト171のダメージも大きくなってしまい、好ましいものではない。

【0096】

更に、自由回転体200は、第一中間転写ドラム31a, 31bの回転軸を支持部材として使用するため、専用の張架ブーリ支持部材は不要であり、また、自由回転体200の設置スペースが不必要に拡大することはない。

【0097】

また、本実施の形態に係るベルト駆動装置160は、上述したものに限定されるものではなく、例えば図21に示すように設計変更しても差し支えない。

図21に示すベルト駆動装置160は、減速機構を用いた形態を利用したものである。

同図において、減速機構は、駆動ブーリ221が回転支持される軸220へ駆動モータ（図示せず）より駆動力が入力され、ベルト伝達により回転速度を減速

させ、出力軸へ駆動力を伝達するものである。

ここで、従動ブーリ231, 232の回転軸は共通であり、この回転軸には、駆動モータからの入力を受ける駆動ブーリ221と従動ブーリ231とに第一の平ベルト241を掛け渡し、一方、従動ブーリ232と出力軸250に設けられた従動ブーリ251との間に第二の平ベルト242を掛け渡したものである。

【0098】

このような減速機構において、出力軸250に大きな負荷がかかっている場合、第一の平ベルト241と第二の平ベルト242とでは、ベルトにかかる引っ張り負荷は異なり、第二の平ベルト242の方が大きな引っ張り負荷力を受けることになる。そのため、滑り等の点で第一の平ベルト241で十分であった巻き付け角度でも第二の平ベルト242では不十分となってしまう虞れがある。

このような状況下において、第二の平ベルト242が巻きかかる従動ブーリ251への巻き付け角度を大きくする場合には、図21に示すように、駆動ブーリ221の回転軸（入力軸）220にこの軸220と同軸で且つ自由回転自在な自由回転体200を設け、この自由回転体200に対し、第二の平ベルト242を巻き付けることで、余計な張架ブーリ支持部材を設けることなく、かつ、スペースを必要とすることなく、従動ブーリ232、従動ブーリ251に対する第二の平ベルト242が巻き付く角度を増加させることが可能となる。

【0099】

尚、実施の形態2に係る画像形成装置のベルト駆動装置に本実施の形態に示すベルト駆動装置160（自由回転体200を使用した態様）を適用してもよいことは勿論である。

【0100】

◎実施の形態8

図22(a)は本発明が適用されたベルト駆動装置の実施の形態8を示す。

本実施の形態に係るベルト駆動装置100は、実施の形態1と略同様に、各感光体ドラム11(11K~11C)、第一中間転写ドラム31a, 31b、及び、第二中間転写ドラム32を駆動するものであり、二つの平ベルト401, 402と、これらの平ベルト401, 402が張架せしめられる各種張架部材とを備

えている。

ここで、張架部材としては、各感光体ドラム11(11K~11C)、第一中間転写ドラム31a, 31b、及び、第二中間転写ドラム32のそれぞれ軸方向一端に取り付けられた従動ブーリ111~117と、各平ベルト401, 402の取り回しを行うための張架ブーリ121, 122とがある。

尚、本実施の形態では、第二中間転写ドラム32に取り付けられた従動ブーリ117は第一、第二の平ベルト401, 402がそれぞれ掛け渡される二段のベルト掛け渡し面を有している。

【0101】

特に、本実施の形態で用いられる平ベルト401, 402は、図22(b)に示すように、2枚のベルト材411, 412を一部固定して重合配置したものである。

そして、本実施の形態では、平ベルト401, 402の貫通孔130配列、各ブーリ突起140配列が複数列に渡って配置されているが、本実施の形態では、この配列に限るものではなく、自由に貫通孔形状、貫通孔配列、ブーリ突起形状、ブーリ突起配列などを設計できる。

【0102】

次に、本実施の形態に係るベルト駆動装置において、平ベルト401, 402とブーリ突起140との噛み合い状態を詳細に説明する。

例えば負荷トルクが発生しているブーリ111等と平ベルト401, 402の噛み合いは、図23(a)に示すように、貫通孔130の片側で接触する。

これは、貫通孔130とブーリ突起140の大きさにクリアランスD1, D2を設けているため、負荷によって平ベルト401, 402の貫通孔130がブーリ111等の突起140を押す(引っ張る)方向で接触を行う。

本実施の形態では、図23(b)に示すように、平ベルト401, 402の厚みが倍となるようにベルト材411, 412を2枚重ねることにより、噛み合いにおける貫通孔130部の変形を抑えることができる。

尚、本実施の形態の平ベルト401, 402は、2枚のベルト材411, 412を独立に伸縮変形可能に重合配置されているため、その曲げ剛性は1枚のベル

ト材と大差なく、プーリ111等に対して安定的に巻き付けられる。

【0103】

一方、ベルト材1枚からなる平ベルト401'，402'にあっては、図24に示すように、貫通孔130部の強度が負荷トルクの大きさに耐えられないような場合には、貫通孔130部はプーリ111等の突起140に乗り上げるように変形し、変形した平ベルト401'，402'の貫通孔130部がプーリ111等から離れる時に変形が回復する。

しかし、変形が大きすぎる場合には、平ベルト401'，402'の貫通孔130部は、図24中、Aで示すように、塑性変形してしまい、次回の噛み合い以後では、回復されない変形をした貫通孔130部がプーリ突起140と噛み合うことになり、プーリ111等へ伝達する回転量がばらついてしまう。また、変形・回復動作を駆動中に繰り返すことにより、平ベルト401'，402'の貫通孔130部は次第に強度が低下していき、最悪、貫通孔130部に亀裂が生じ破壊を招くことになる。

【0104】

また、本実施の形態において、平ベルト401，402の製造例を図25に示す。

本例は、2枚のベルト材411，412を重ねて端部を合わせた後、その端部を溶接等により結合させる例を示す。

ここでは、2枚のベルト材411，412の位置関係を合わせるため、または、ベルト材411，412の蛇行方向が異なった場合における本実施の形態の効果の低下を防止するために、溶接等を行い結合するようにしている。

しかし、ベルト材411，412幅が短い場合などには、ベルト材411，412の両側の周長差を容易に小さく製作できるため、周長差によって発生する蛇行の方向がばらつくことがない。そのため、2枚のベルト材411，412が各自別な方向へ蛇行するということは希である。ほとんどの場合、プーリが傾くことによって蛇行するため、同じプーリに巻きかけられている2枚のベルト材411，412は同一方向に蛇行する。

このような場合には、2枚のベルト材411，412を端部で結合せず独立に

使用することができる。但し、貫通孔130位置がずれることは回避しなければならないので、少なくとも一部を固定することが必要である。

【0105】

図25に示す例では、2枚の長さ調整および貫通孔ピッチが調整されたシート状のベルト材411, 412を重ね合わせ、両端部を突き合わせ同時に溶接することにより、溶接部分で2枚のベルト材411, 412が結合することができる。

溶接部に段差が生じることを防止するためには、図にあるように突き合わせ溶接することが好ましい。また、ここでは、1ヶ所のみ溶接しているが、複数箇所を溶接しても構わない。更に、溶接ではなく、2枚のベルト材411, 412を接着剤によって結合しても構わない。

例えば溶接時には、図26に示すように、貫通孔位置、貫通孔間隔などの位置を決めるための治具421を用いて溶接装置420にて溶接することにより、溶接時の歪みや貫通孔位置関係のばらつきなどを抑えることが可能となる。

【0106】

【実施例】

◎実施例 1

実施の形態1に係る画像形成装置を実施例モデルとし、出力画像の濃度ムラや画像位置ずれについて実際に調べたところ、本発明者らの実験によれば、孔無し平ベルトでは滑りが生じ駆動不可能な従動プーリ軸トルクが作用する条件下であっても、出力画像の濃度ムラや画像位置ずれは認知限界以下にまで低減させることに成功した。

その一例を図27に示す。

同図では、ベルトの貫通孔部とプーリ突起との噛み合い変動を目標レベルとする $\Delta V_{0-p} < 0.3\%$ とすることができます、画像濃度ムラの認知限界以下にすることができた。

【0107】

また、本実施例によれば、ベルト初期張力を大きくすることで発生するベルト蛇行による影響も低減できた。

その一例を図28に示す。尚、図29に比較例（ベルト貫通孔が1列孔）の場合の結果を示す。

先ず、比較例について検討して見るに、図29には、①従動プーリに負荷を与えるにベルト張力を $T_0 \rightarrow T_1$ へ上げていき（C1領域参照）、次に、②ベルト張力を T_1 へ戻し、負荷を目標とする値の半分だけ従動プーリに与え、先程と同様にベルト張力を $T_1 \rightarrow T_0$ へ上げていき（C2領域参照）、更には、③ベルト張力を T_0 へ戻し、負荷を目標とする値で与え、ベルト張力を $T_0 \rightarrow T_1$ へ上げていった（C3領域参照）連続駆動時の回転ムラレベル経過が示されている。

【0108】

同図から分かるように、①から②へ変更する場合には、ベルト張力を初期状態に戻しているにも関わらず回転ムラのレベルは、初期状態に戻っていないことが分かる。これは、①が無負荷駆動であるため負荷による影響ではなく、ベルト張力を T_1 まで上げていくときに、ベルト蛇行が発生し、貫通孔部にダメージを与えたものである。

また、負荷を加えた②、③では、回転ムラレベルが次第に悪化しており、負荷とこのベルト蛇行の影響が入り交じっていることが分かる。

実験終了後にベルト貫通孔部を観察した所、突起との噛み合いで生じたダメージが塑性変形しており、ある所では亀裂が生じていた。このような現象が生じてしまうと画像形成装置としてはもちろん、駆動力伝達装置としての役割を果たすことが困難となってしまう。

【0109】

これに対し、本実施例を導入した結果を見ると、図28には、①ベルト張力を T_0 とし、従動プーリに負荷を0から徐々に目標値に挙げていき（A1領域参照）、次に、②ベルト張力を T_0 へ戻した後、ベルト張力を T_1 （ $T_0 \times 1.4$ ）とし、従動プーリに負荷を0から徐々に目標値に挙げていき（A2領域参照）、更には、③ベルト張力を T_1 へ戻した後、ベルト張力を T_2 （ $T_0 \times 1.7$ ）とし、従動プーリに負荷を0から徐々に目標値に挙げていった（A3領域参照）連続駆動時の回転ムラレベル経過が示されている。

同図によれば、従動プーリの負荷を上げていくと回転ムラが多少悪化する傾向

が見られるが、そのレベルは小さく、また、ベルト張力を上げることにより発生する蛇行の影響もほとんどない。すなわち、実験途中に、ベルト張力を初期状態に戻し、無負荷とした時は、回転ムラのレベルも初期状態にもどっており、再現性がある。

逆に、ベルト張力を上げることによりブーリとベルトとのグリップ力が上がり、噛み合いによって生じる回転ムラが低減している。

よって、本実施例の導入により、出力画像の濃度ムラ認知限界である ΔV_{0-p} を0.3%以下とすることができます、かつ、負荷やベルト蛇行に対しても信頼性の高い駆動力伝達方式を提供することができた。

【0110】

◎実施例2

実施の形態7に係る画像形成装置を実施例モデルとし、出力画像の濃度ムラや画像位置ずれについて実際に調べたところ、本発明者らの実験によれば、孔無し平ベルトを使用した態様であっても、ブーリに対する平ベルトの巻き付け角度を充分に大きくすることができるため、平ベルトとブーリとの間の滑りは有效地に回避することが可能である。

また、孔無し平ベルトでは滑りが生じ駆動不可能な従動ブーリ軸トルクが作用する条件下であっても、出力画像の濃度ムラや画像位置ずれは認知限界以下にまで低減させることに成功した。

その一例を図30に示す。

同図によれば、ベルトの貫通孔部とブーリ突起との噛み合い変動を目標レベルとする $\Delta V_{0-p} < 0.3\%$ とすることができます、画像濃度ムラの認知限界以下にすることができた。

【0111】

【発明の効果】

以上詳細に説明したように、本発明に係る駆動力伝達装置によれば、複数の張架部材に無端状の平ベルトを掛け渡すことで駆動力を伝達する方式において、平ベルトの進行方向に沿って配列する貫通孔構造と、平ベルトが掛け渡される張架部材の少なくとも一つに設けられる突起構造とを工夫（複数の貫通孔、突起配列

、長孔状貫通孔と柱状突起との組合せ)し、貫通孔と突起との係合状態を確実に保ちながら、かつ、貫通孔部への作用力の集中を回避する構造としたので、平ベルトと張架部材との間の滑りを有効に防止できることは勿論、張架部材のいずれかに連結される被駆動体に大きな回転負荷がかかる状態であっても、貫通孔部に作用する力を効果的に分散でき、貫通孔部の破壊を有効に防止しながら、被駆動体に対し安定的に駆動力を伝達することができる。

このため、このような駆動力伝達装置を用いた画像形成装置にあっては、孔付き平ベルトの貫通孔部の破壊を有効に抑え、被駆動体である像担持体に対し安定的に駆動力を伝達することができるので、孔付き平ベルトの寿命を延ばしながら、画像欠陥のない出力画像を得ることができる。

【0112】

また、本発明に係る駆動力伝達装置によれば、複数の張架部材に無端状の平ベルトを掛け渡すことで駆動力を伝達する方式において、駆動力が伝達せしめられる張架部材の少なくとも一つに当該張架部材の回転軸に対して自由回転可能な自由回転体を同軸に設け、この自由回転体が設けられた張架部材とは異なって隣接し合う張架部材に対し平ベルトを前記自由回転体を介して掛け渡すようにしたので、例えば隣接し合う張架部材に対する平ベルトの巻き付け角度を大きく設定することが可能になり、しかも、自由回転体の設置スペースとして独自のスペースを必要としないで済む。

このため、例えば隣接し合う張架部材の少なくとも一方に被駆動体を連結する態様において、被駆動体に大きな回転負荷がかかる状態であっても、平ベルト引き回しのための補助張架部材支持部材の設置スペースを独自に必要とせず、レイアウトスペースを不必要に広げることなく、被駆動体に対し安定的に駆動力を伝達することができる。

更に、このような駆動力伝達装置を用いた画像形成装置にあっては、平ベルト引き回しのための独自の補助張架部材支持部材等を不要とし、しかも、被駆動体である像担持体に対し安定的に駆動力を伝達することができるので、装置の大型化を回避しながら、画像欠陥のない出力画像を得ることができる。

【図面の簡単な説明】

【図1】 本発明に係る駆動力伝達装置の概要を示す説明図である。

【図2】 (a) は本発明の別の態様に係る駆動力伝達装置の概要を示す説明図、(b) はその要部説明図である。

【図3】 本発明の更に別の態様に係る駆動力伝達装置の概要を示す説明図である。

【図4】 実施の形態1に係る画像形成装置の全体構成を示す説明図である。

【図5】 実施の形態1で用いられる駆動力伝達装置の詳細を示す斜視説明図である。

【図6】 (a) は実施の形態1で用いられる駆動力伝達装置の正面説明図、(b) はその平面説明図である。

【図7】 (a) は実施の形態1で用いられる駆動力伝達装置の要部を示す説明図、(b) は(a)中B方向から見た矢視図、(c) は(a)中C方向から見た矢視図である。

【図8】 (a) は比較の形態における平ベルトの貫通孔とプーリの突起との噛み合い状態を示す説明図、(b) は本実施の形態における平ベルトの貫通孔とプーリの突起との噛み合い状態を示す説明図、(c) は本実施の形態の変形形態における平ベルトの貫通孔とプーリの突起とのベルト蛇行時の噛み合い状態を示す説明図、(d) は本実施の形態における平ベルトの貫通孔とプーリの突起とのベルト蛇行時の噛み合い状態を示す説明図である。

【図9】 実施の形態1で用いられる駆動力伝達装置の変形形態を示す説明図である。

【図10】 実施の形態2に係る画像形成装置の全体構成を示す説明図である。

【図11】 (a)～(d) は実施の形態3に係る駆動力伝達装置及びその変形形態を示す説明図である。

【図12】 実施の形態4に係る駆動力伝達装置を示す説明図である。

【図13】 (a) は本実施の形態で用いられる張架ロールを示す説明図、(b) は同平ベルトの形状を示す説明図、(c) は同張架ロールの分解斜視図で

ある。

【図14】 本実施の形態に係る駆動力伝達装置の作用を示す説明図である

【図15】 実施の形態5に係る駆動力伝達装置の要部を示す説明図である

【図16】 (a) は実施の形態6に係る駆動力伝達装置の要部を示す説明図、(b) はその作用を示す説明図である。

【図17】 実施の形態7に係る画像形成装置の要部を示す説明図である。

【図18】 実施の形態7で用いられる駆動力伝達装置の概要を示す斜視説明図である。

【図19】 実施の形態7で用いられる駆動力伝達装置を図18の背面側から見た斜視説明図である。

【図20】 (a) は自由回転体の具体例を示す説明図、(b) は自由回転体の軸方向に対する位置規制例を示す説明図である。

【図21】 実施の形態7で用いられる駆動力伝達装置の変形形態を示す説明図である。

【図22】 (a) は実施の形態8に係る駆動力伝達装置を示す説明図、(b) は本実施の形態で用いられる平ベルトの構成を示す説明図である。

【図23】 (a) は本実施の形態に係る駆動力伝達装置の貫通孔部付近を示す説明図、(b) は本実施の形態に係る駆動力伝達装置の作用を示す説明図である。

【図24】 比較の形態に係る駆動力伝達装置の作用を示す説明図である。

【図25】 本実施の形態で用いられる平ベルトの製造法を示す説明図である。

【図26】 図25に示す平ベルトの製造法において端部溶接工程の詳細を示す説明図である。

【図27】 実施例1に係る駆動力伝達装置における従動プーリの回転ムラを示す説明図である。

【図28】 実施例1に係る駆動力伝達装置の駆動結果を示す説明図である

【図29】 比較例に係る駆動力伝達装置の駆動結果を示す説明図である。

【図30】 実施例2に係る駆動力伝達装置における従動プーリの回転ムラを示す説明図である。

【図31】 従来の駆動力伝達装置の不具合を示す説明図である。

【図32】 従来の駆動力伝達装置を用いた画像形成装置において濃度ムラ許容値と像担持体の回転ムラとの関係を示す説明図である。

【図33】 従来の平ベルトを用いた駆動力伝達装置における従動プーリの平均回転速度と負荷トルクとの関係を示す説明図である。

【図34】 従来の平ベルトを用いた駆動力伝達装置の一例を示す説明図である。

【図35】 (a) は従来の平ベルトを用いた駆動力伝達装置の他の例を示す説明図、(b) は(a) 中B方向から見た矢視図である。

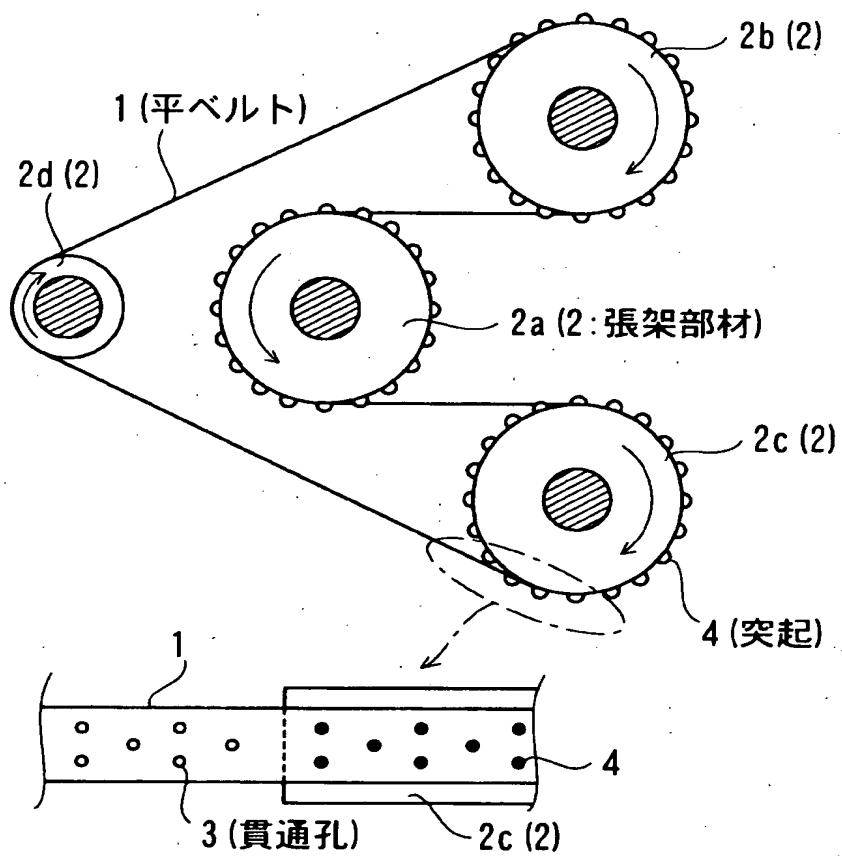
【図36】 図35に係る駆動力伝達装置における従動軸負荷と従動プーリ回転平均速度との関係を示す説明図である。

【符号の説明】

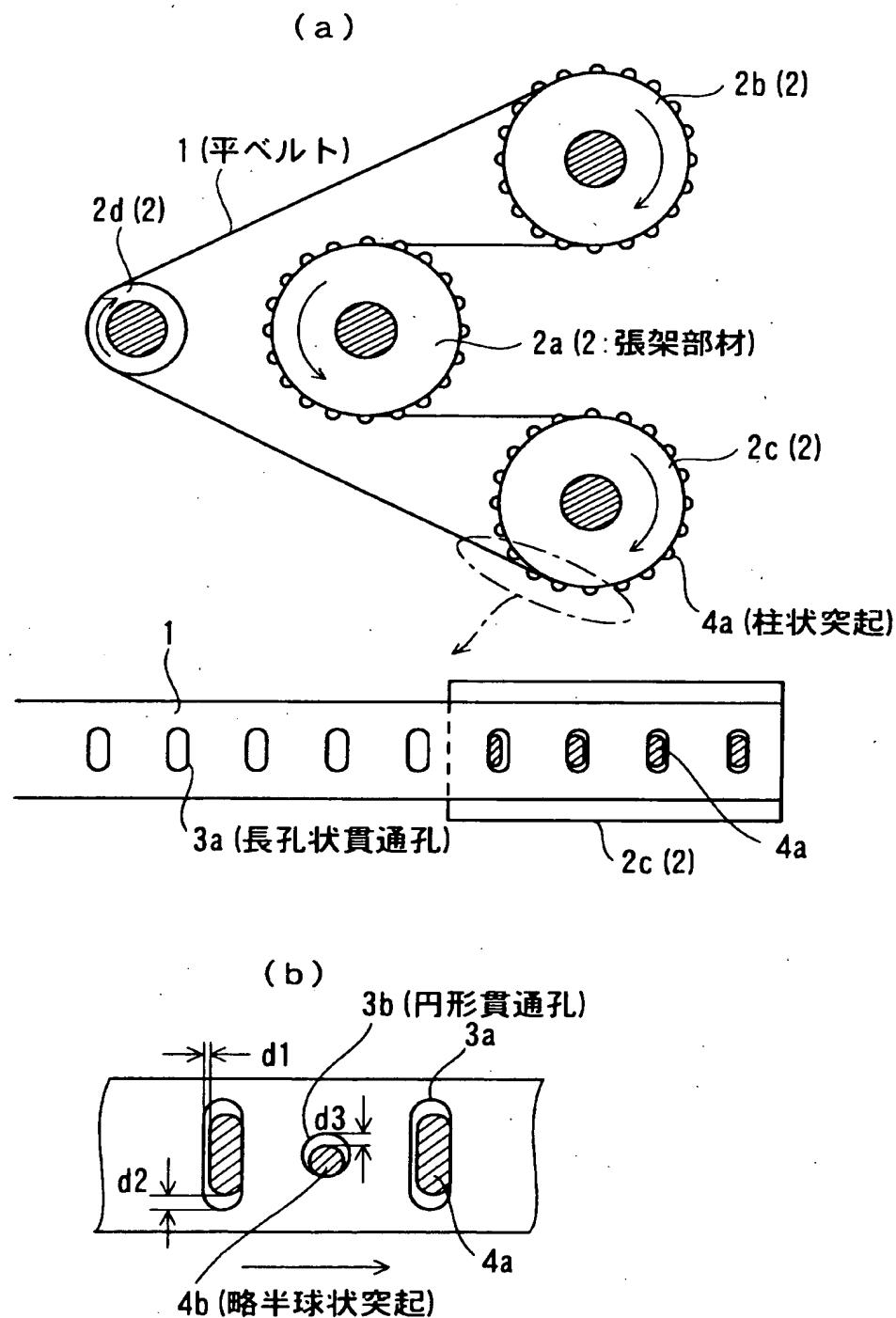
1 … 平ベルト, 2 (2a ~ 2d) … 張架部材, 3 … 貫通孔, 3a … 長孔状貫通孔, 3b … 円形貫通孔, 4 … 突起, 4a … 柱状突起, 4b … 略半球状突起, 5 … 自由回転体

【書類名】 図面

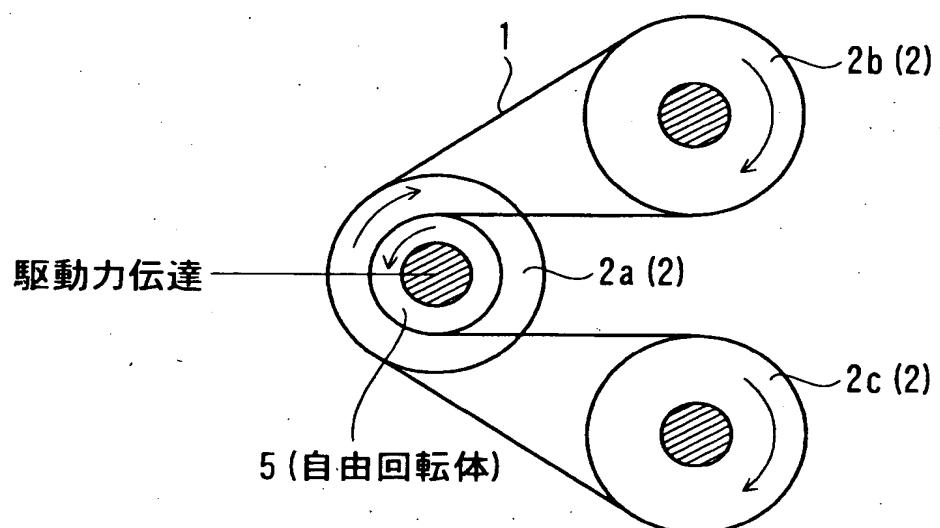
【図1】



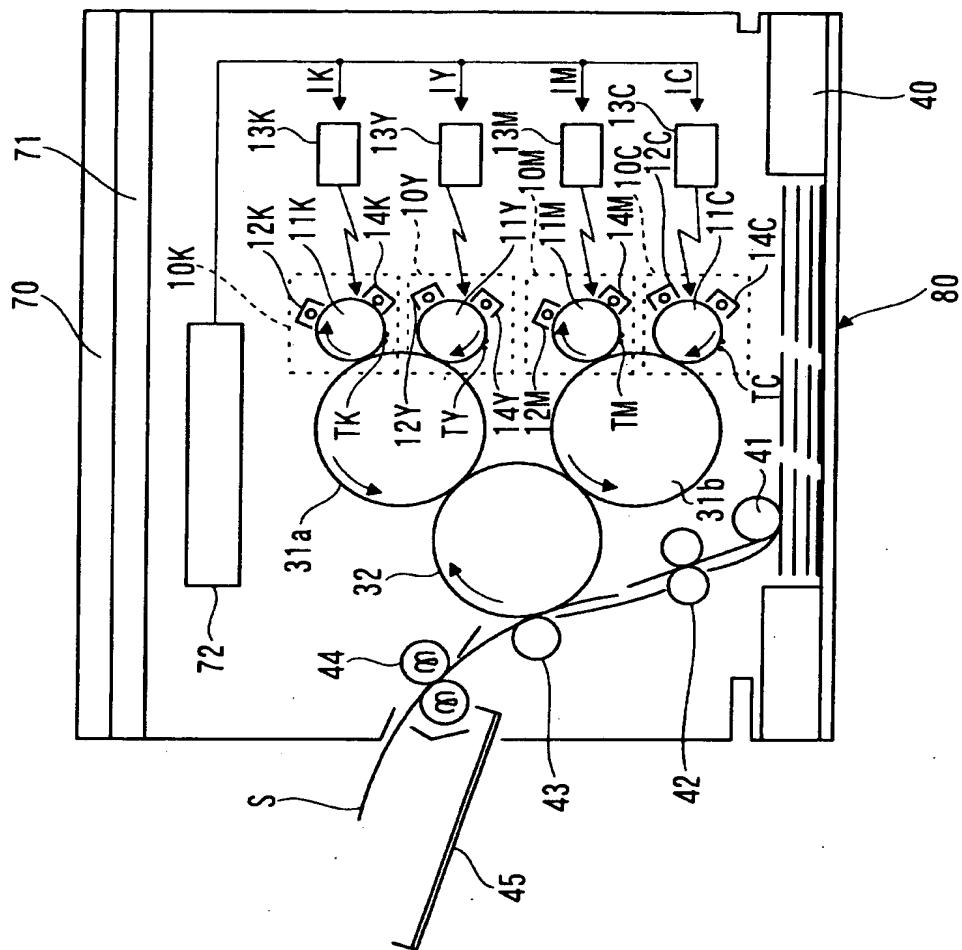
【図2】



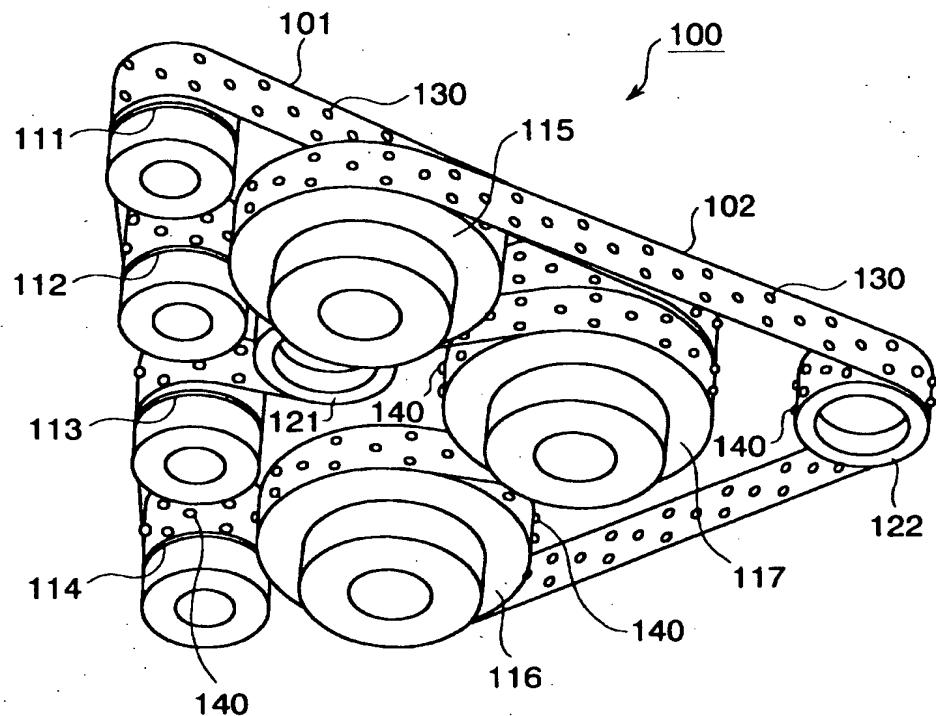
【図3】



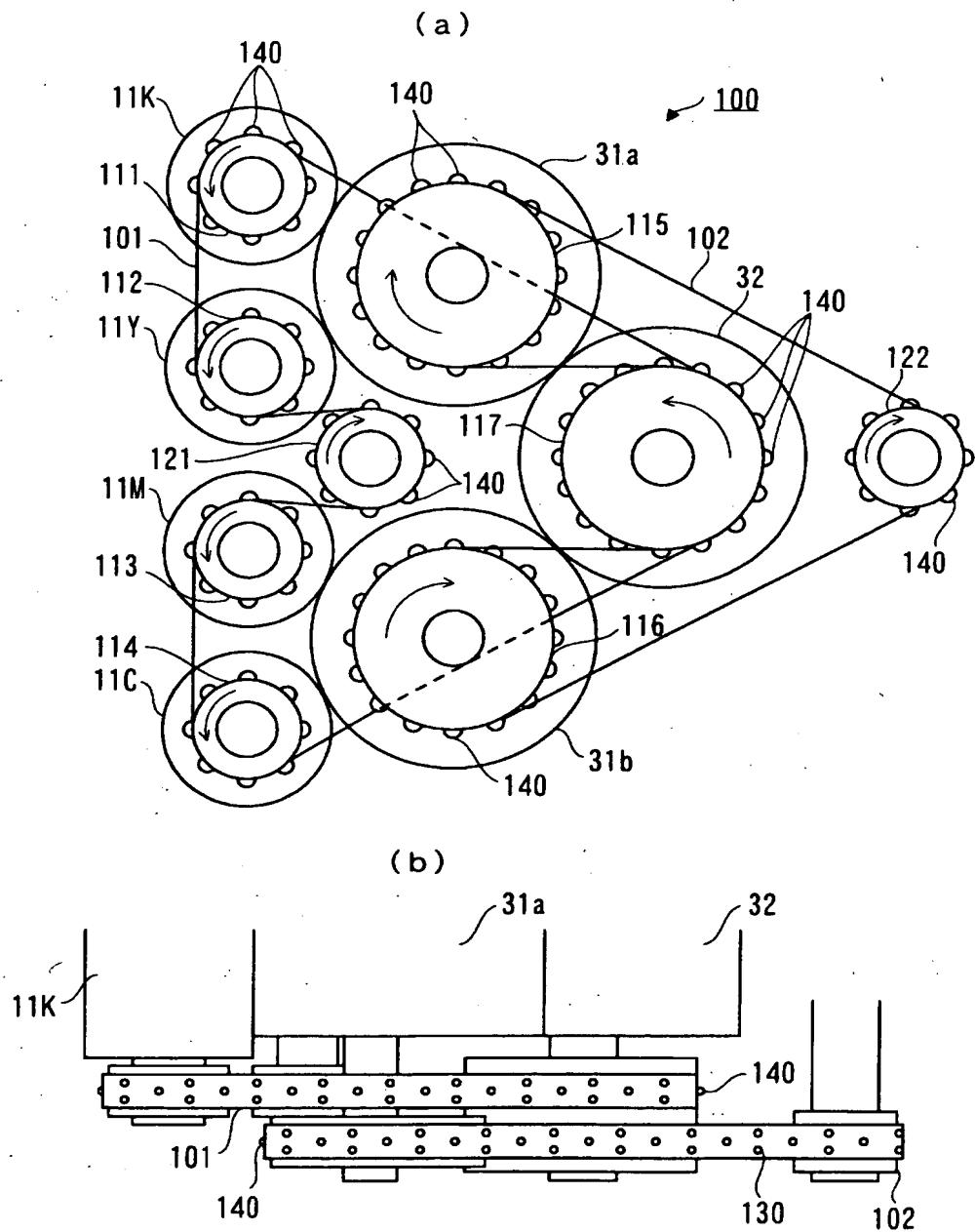
【図4】



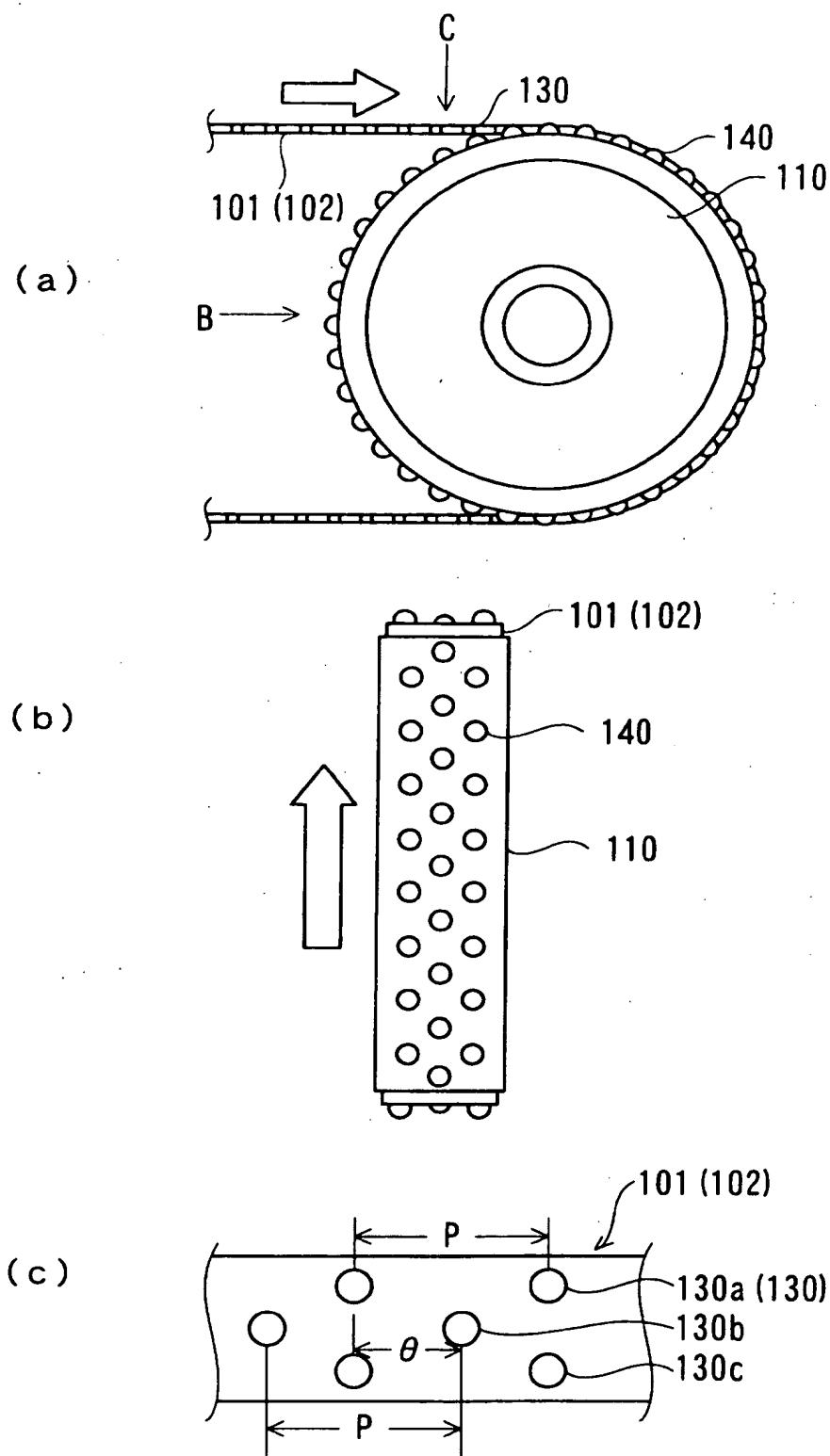
【図5】



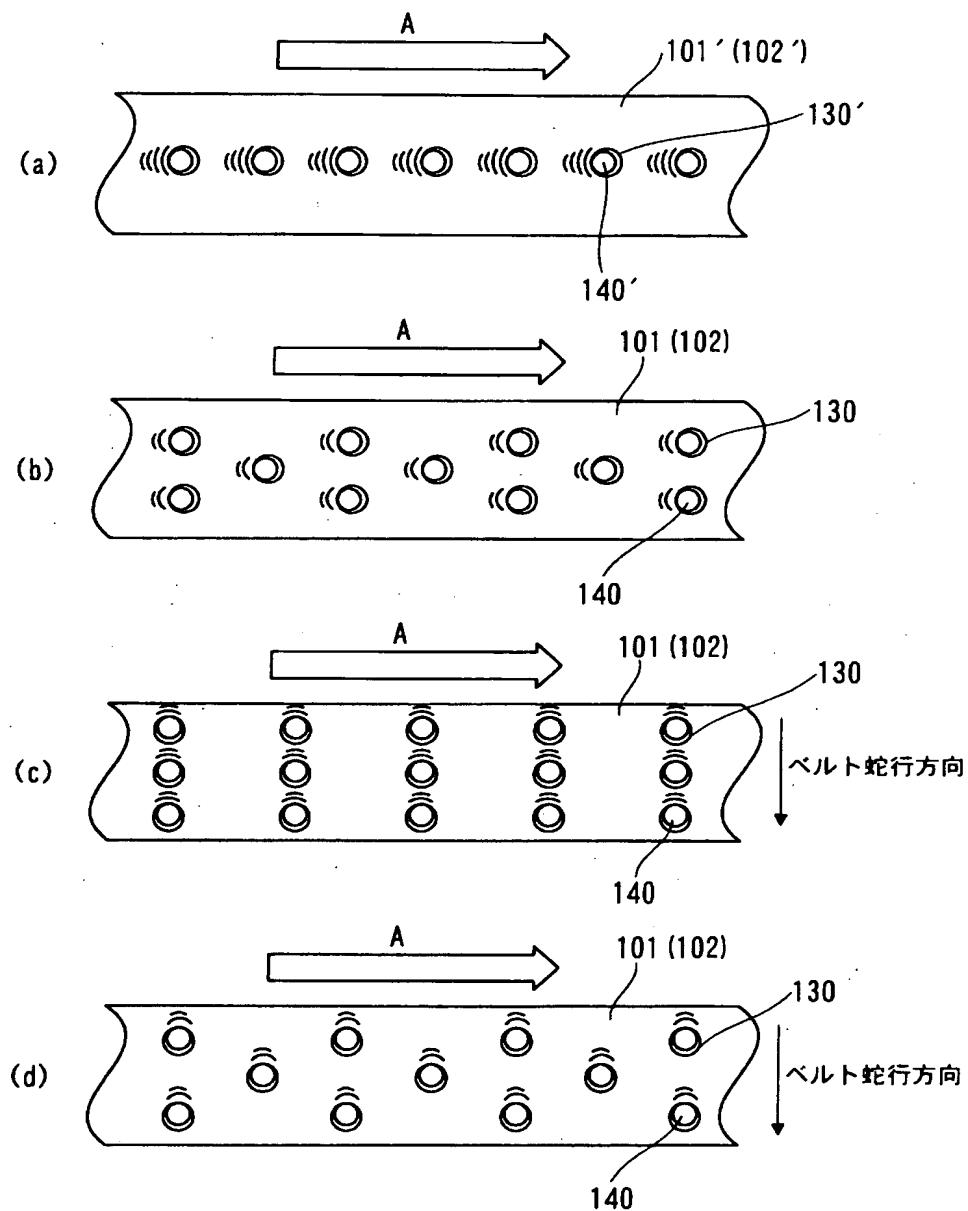
【図6】



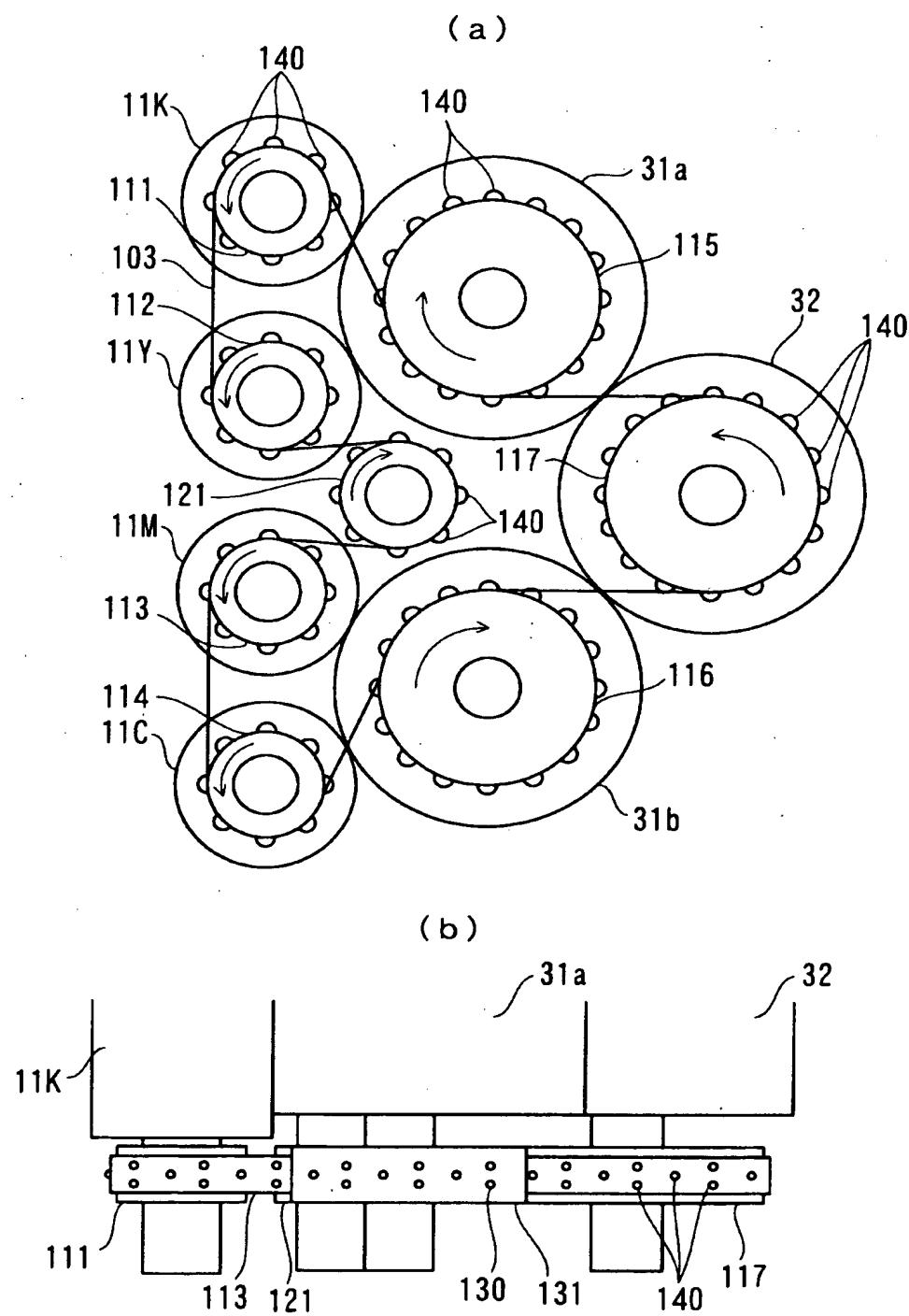
【図7】



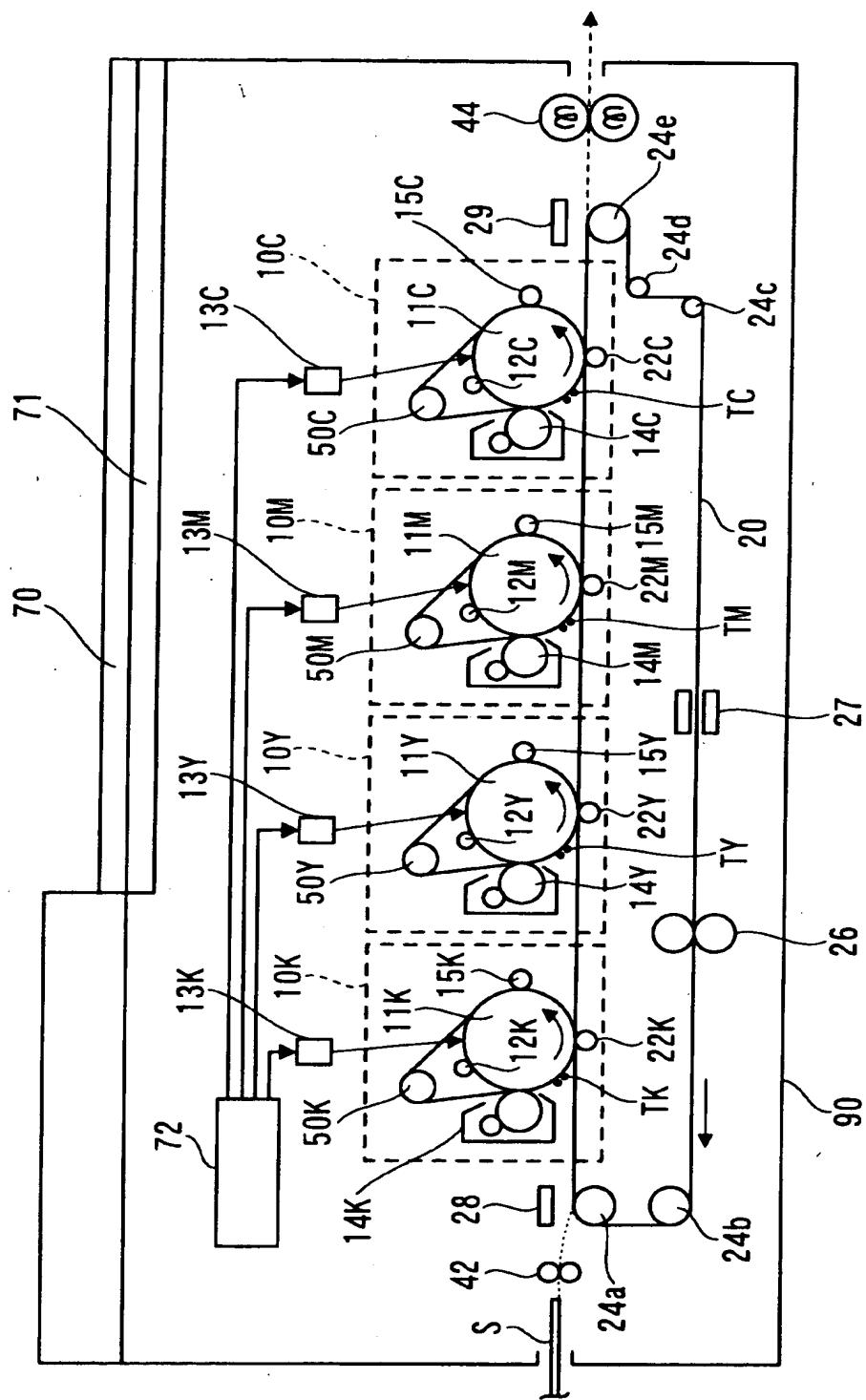
【図8】



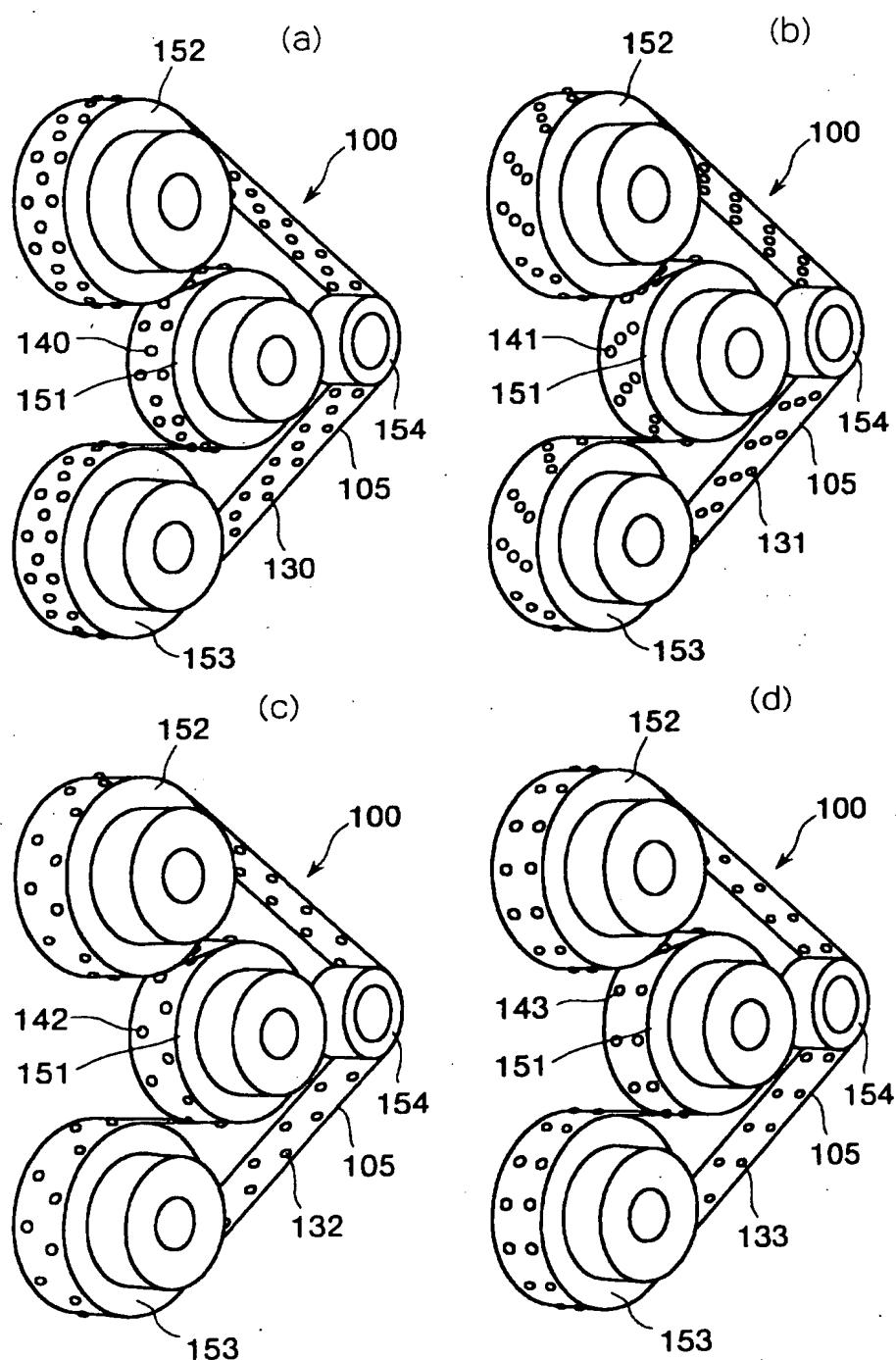
【図9】



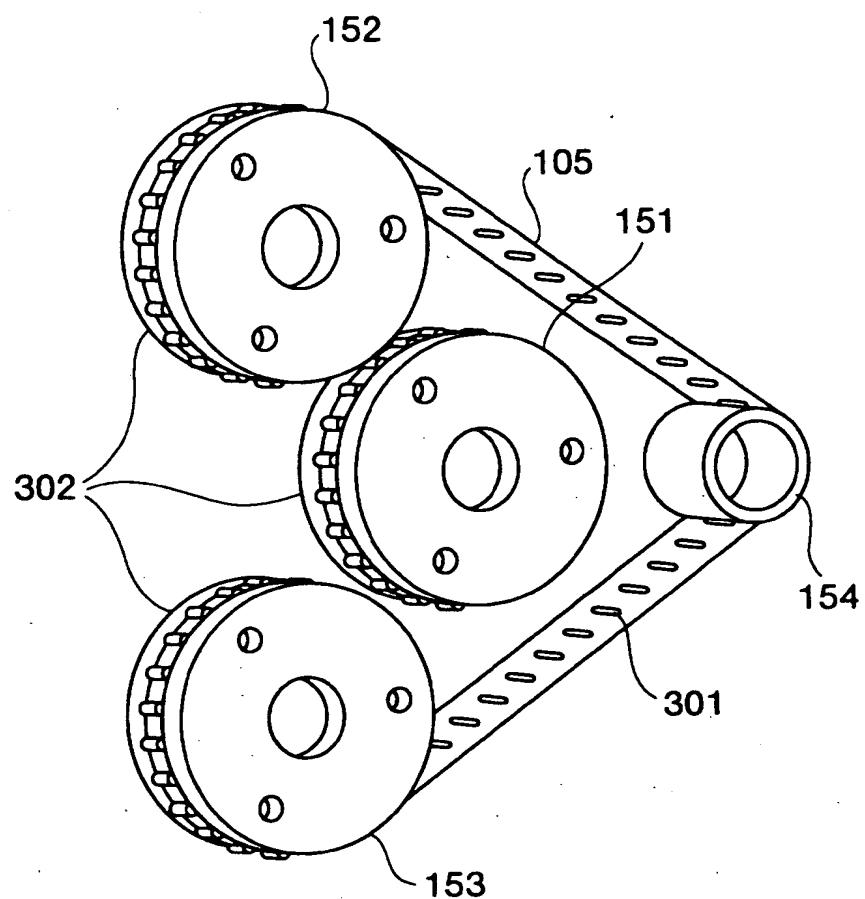
【図10】



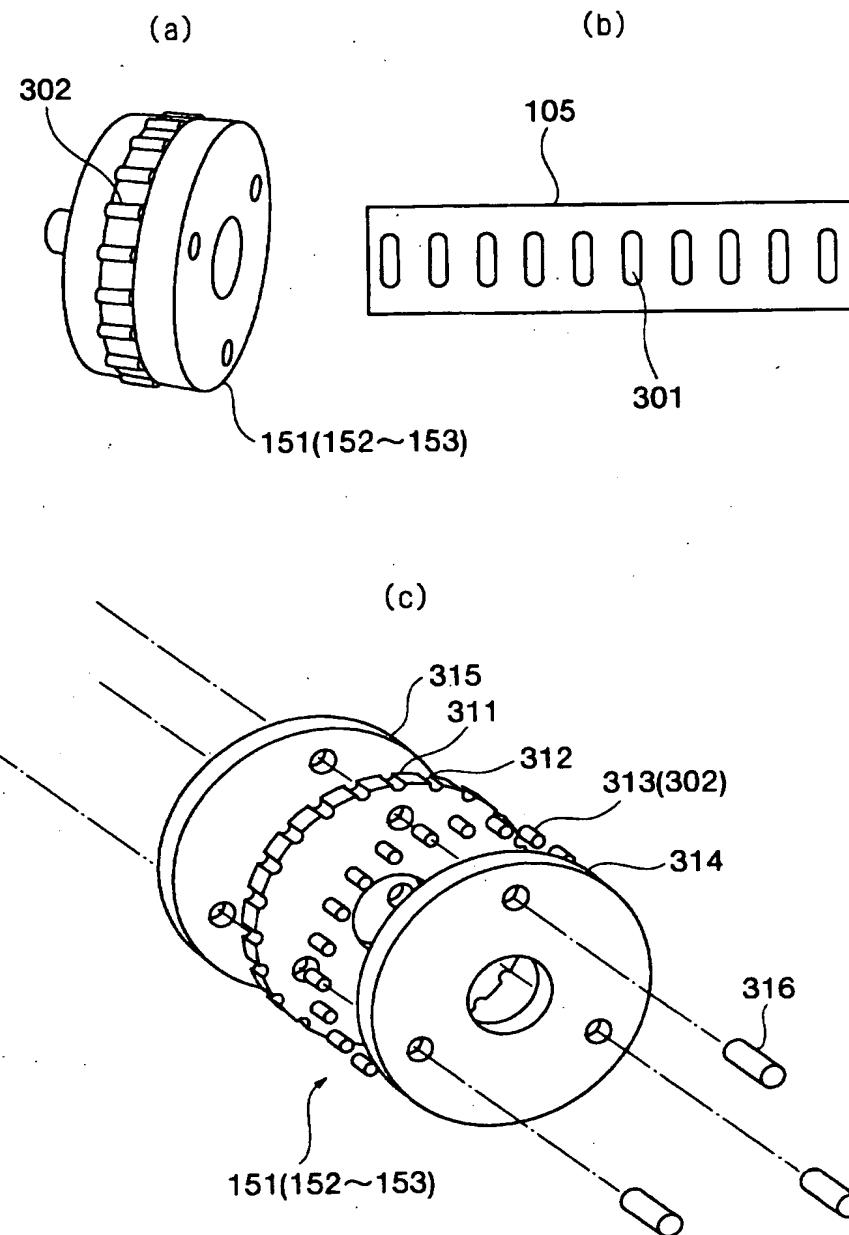
【図11】



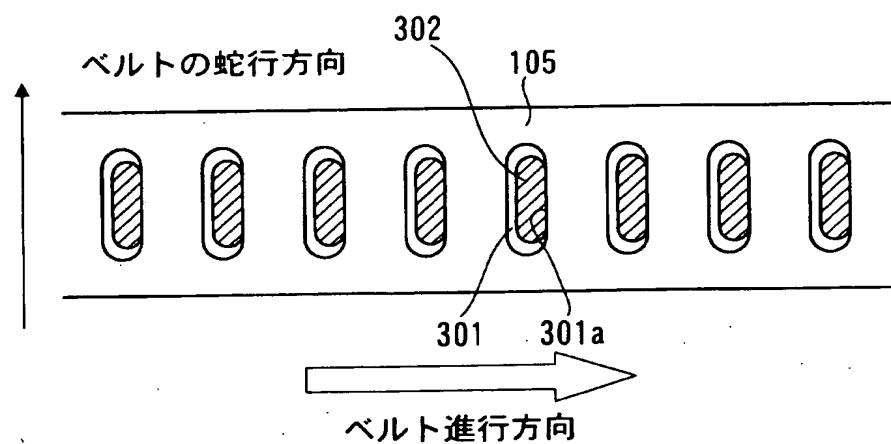
【図12】



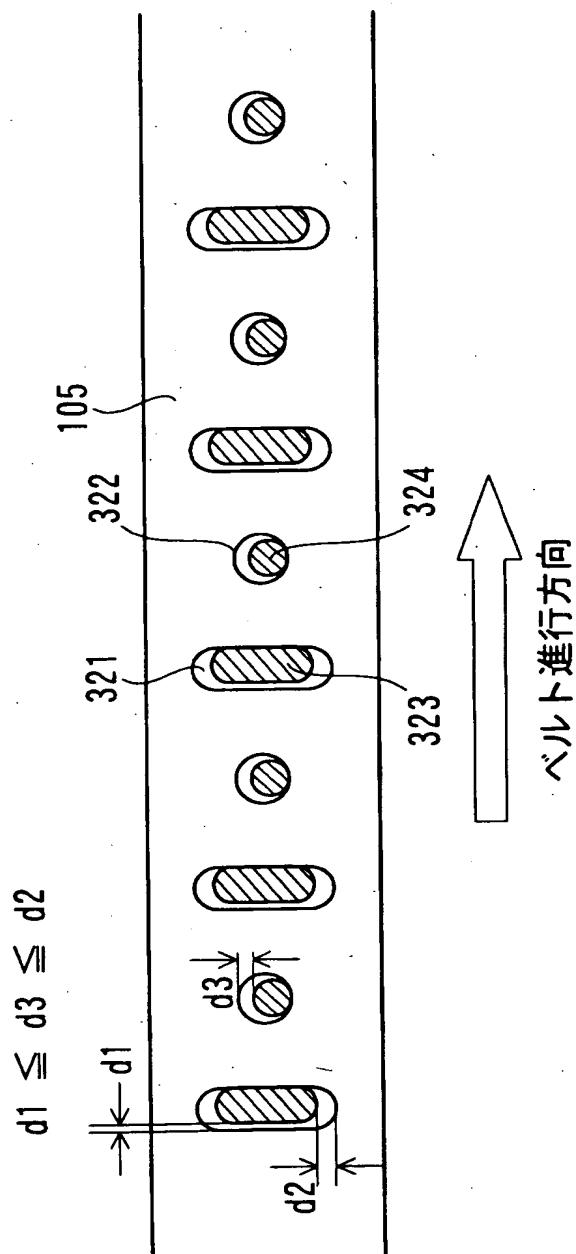
【図13】



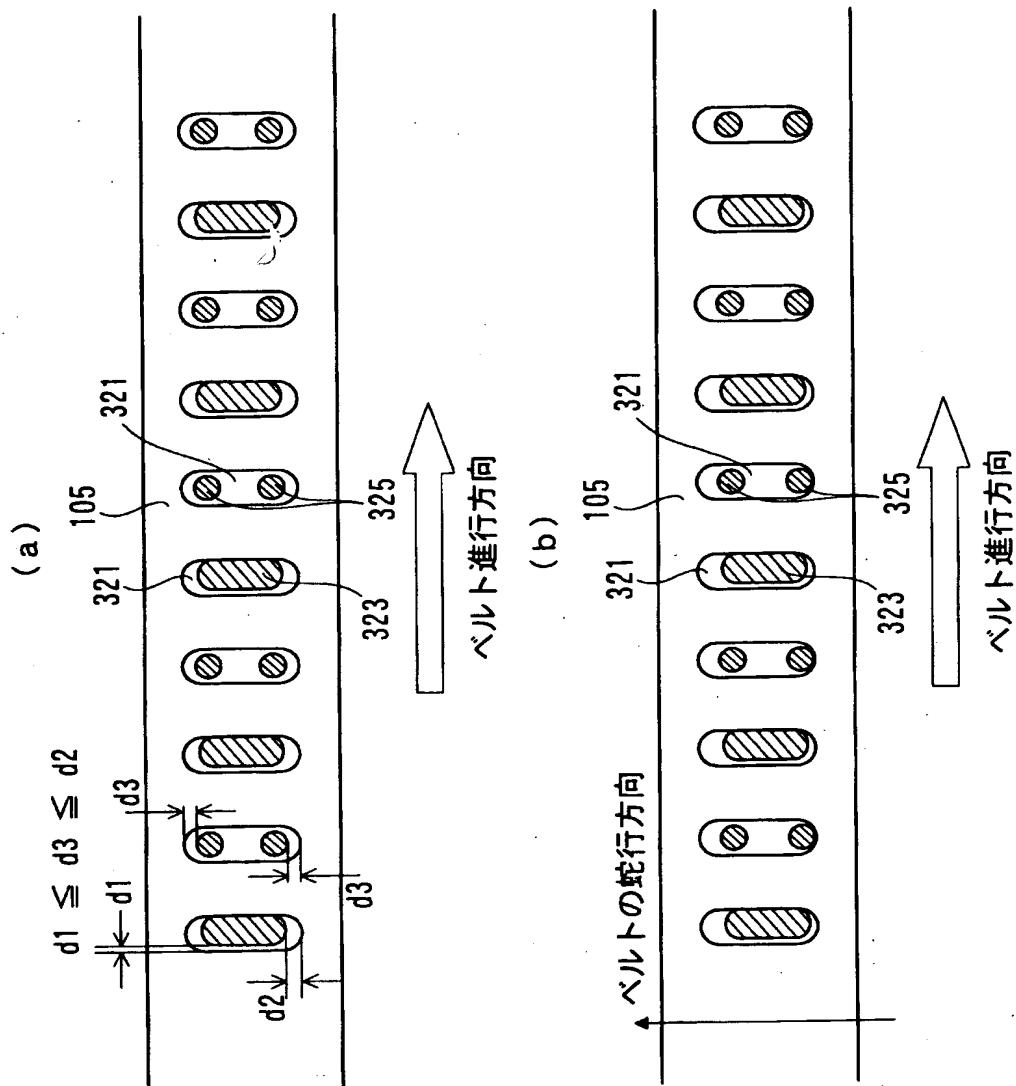
【図14】



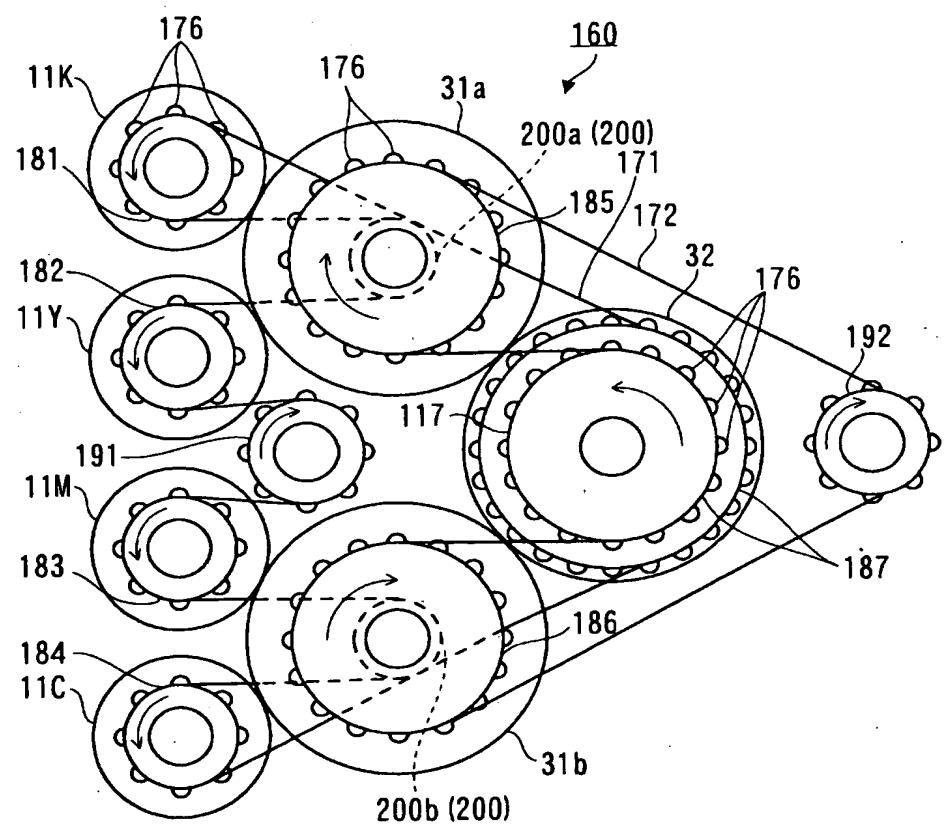
【図15】



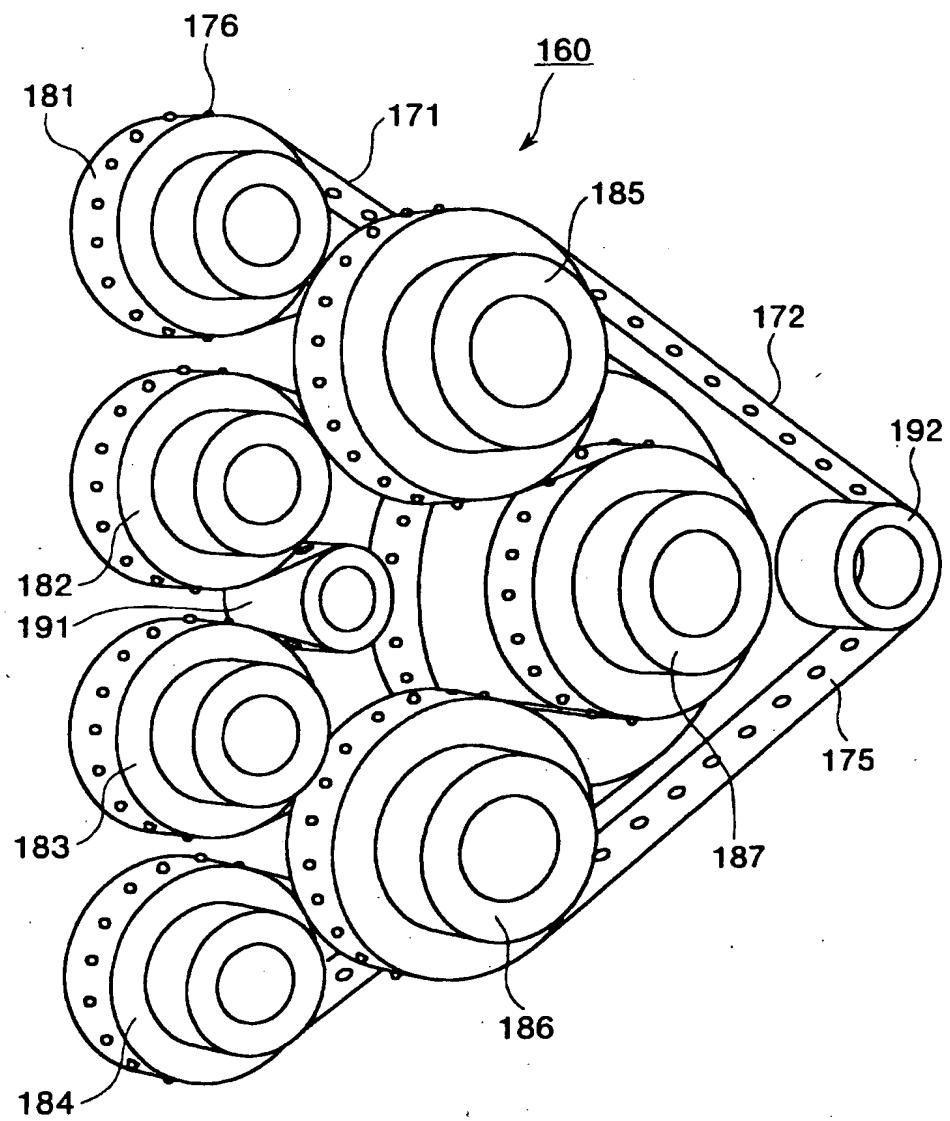
【図16】



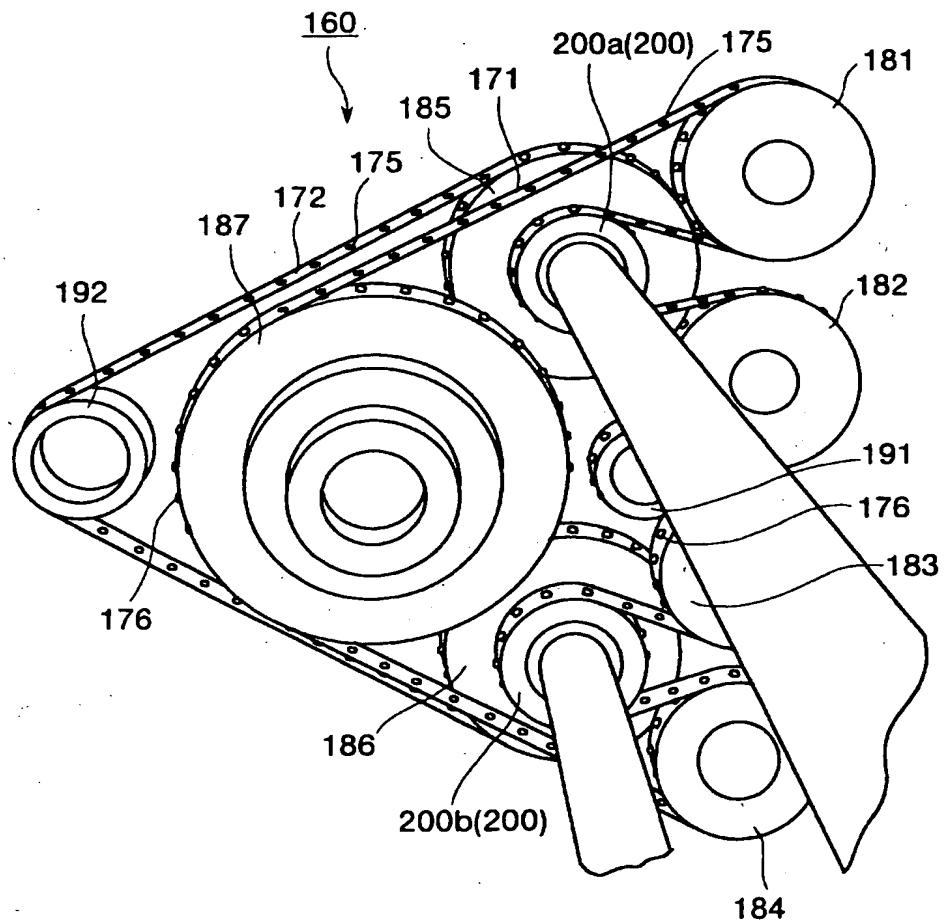
【図17】



【図18】

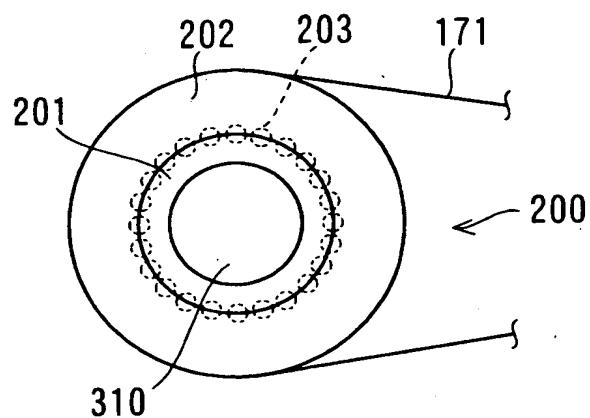


【図19】

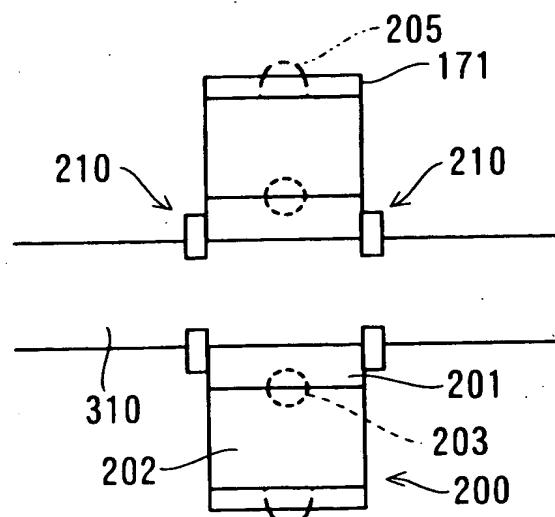


【図20】

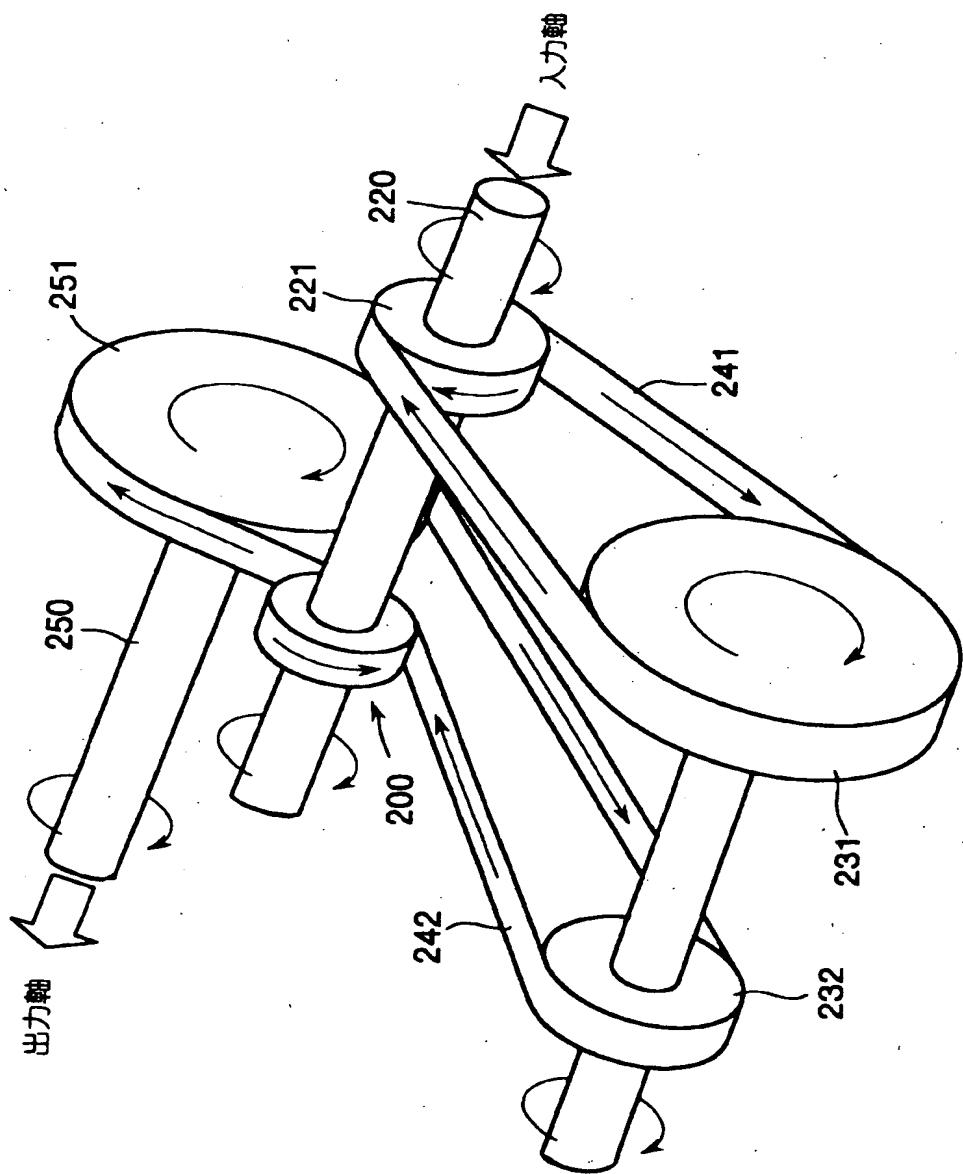
(a)



(b)

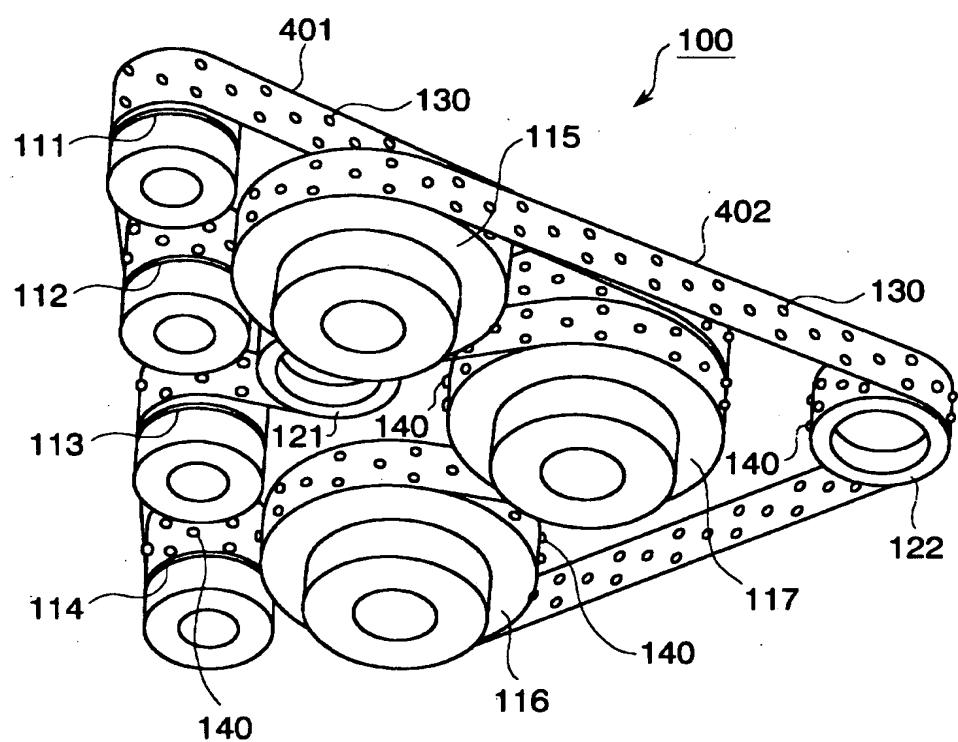


【図21】

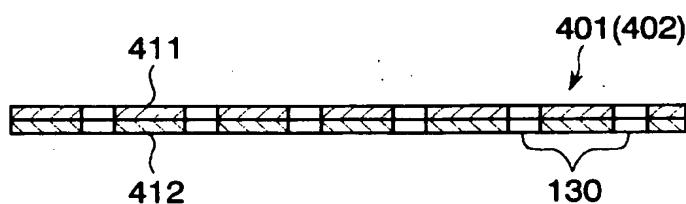


【図22】

(a)

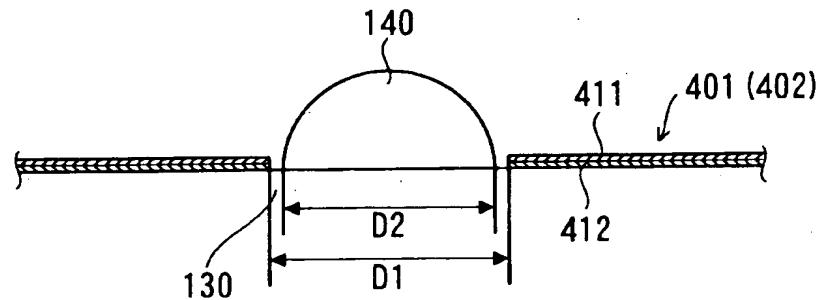


(b)

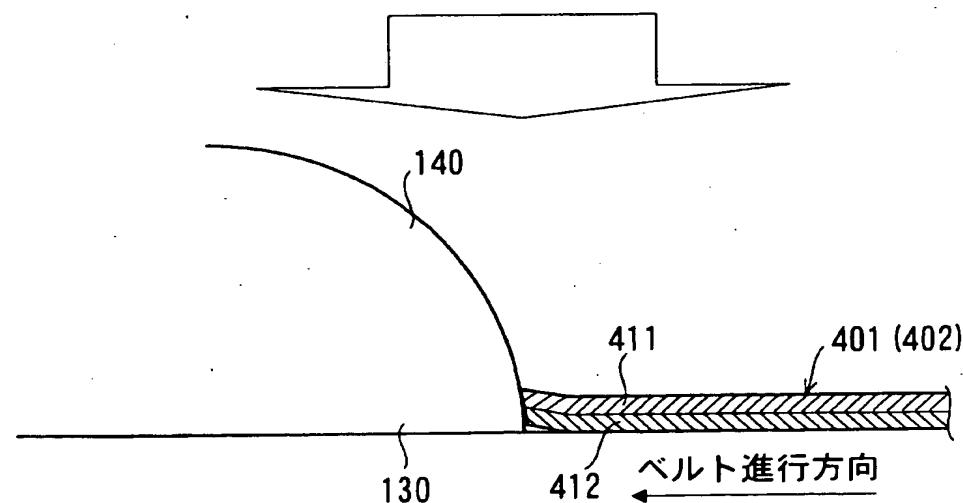
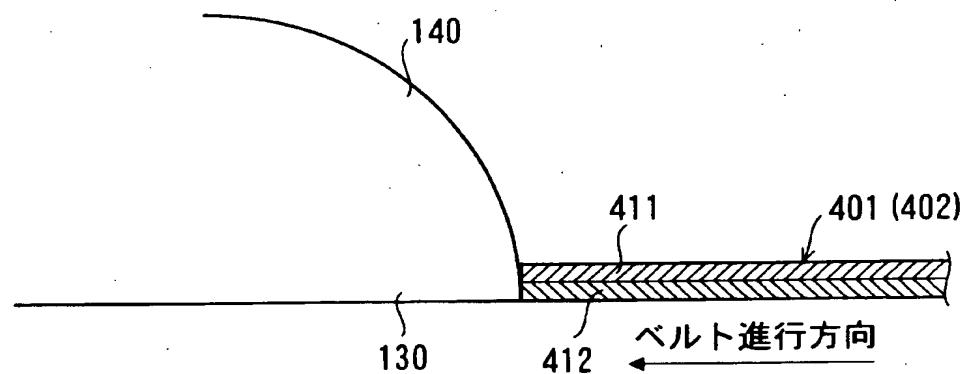


【図23】

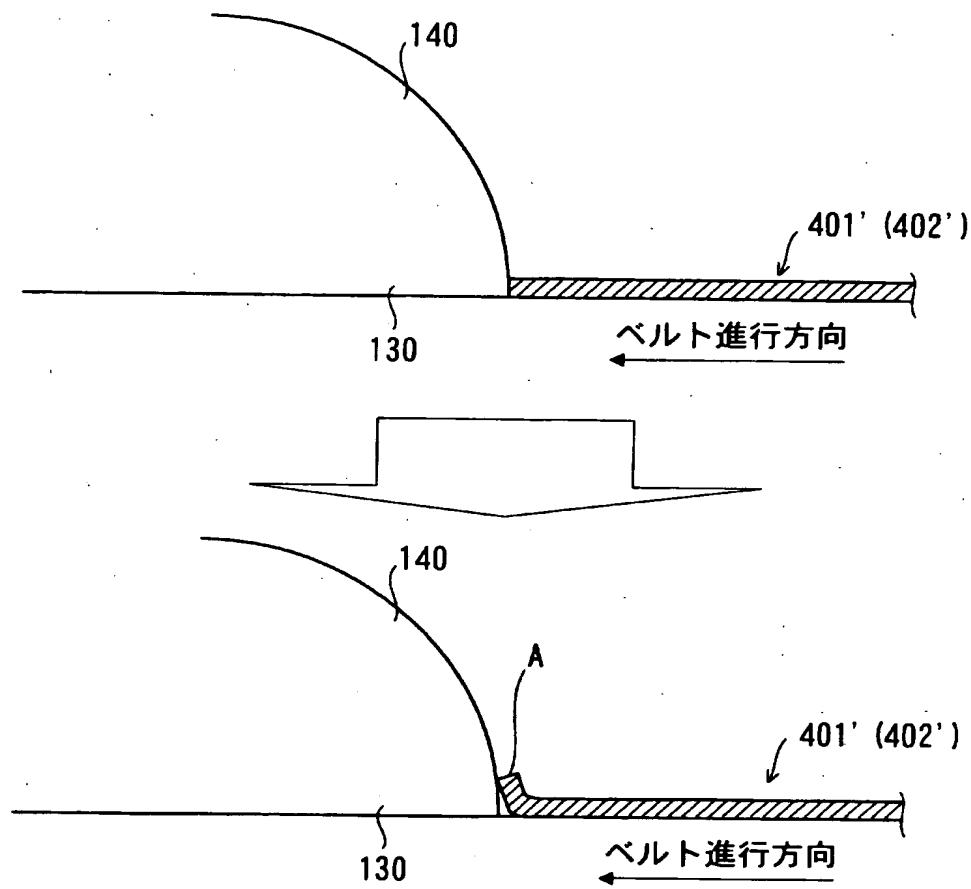
(a)



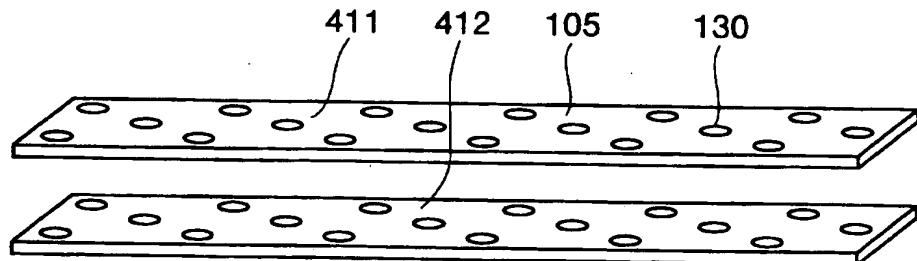
(b)



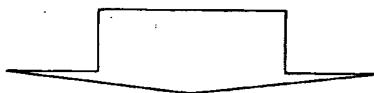
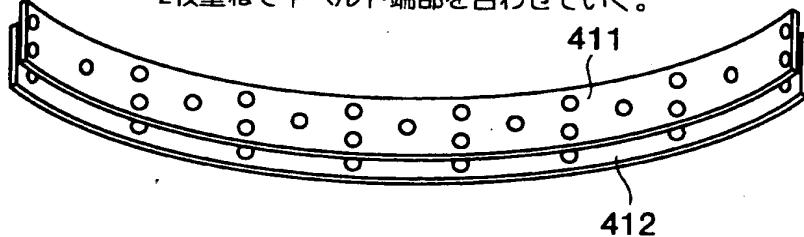
【図24】



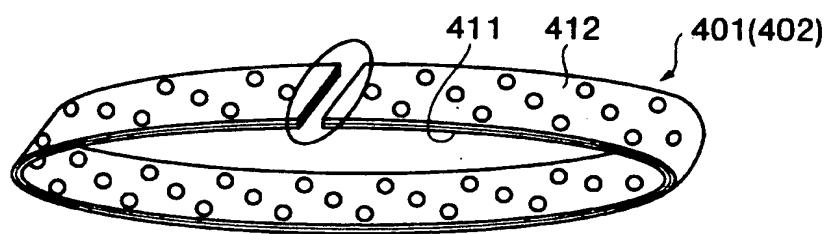
【図25】



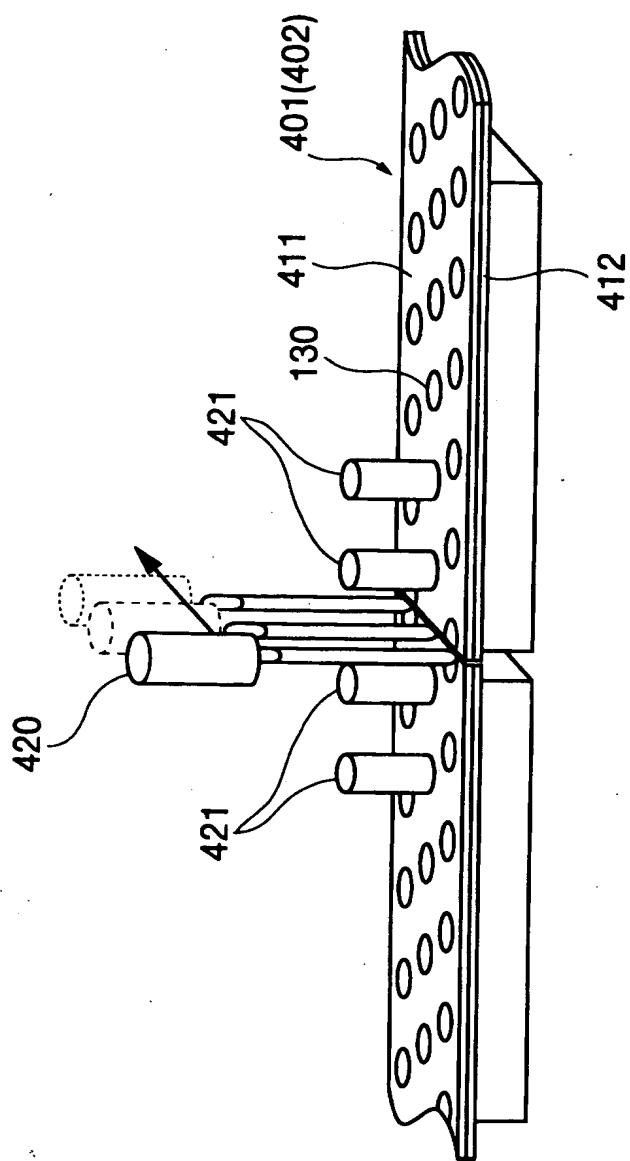
2枚重ねて平ベルト端部を合わせていく。



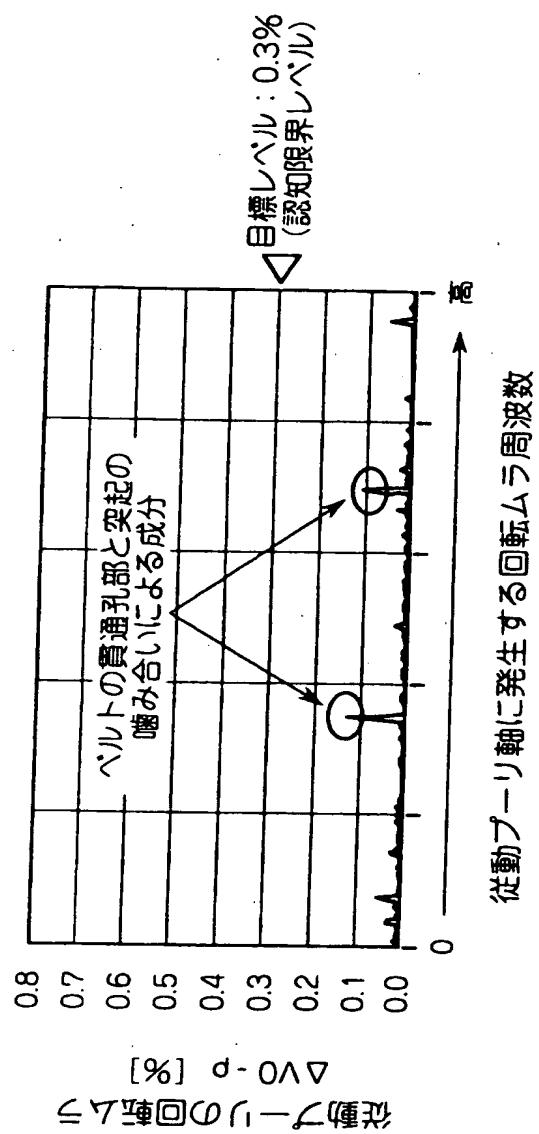
2枚重ねた平ベルト端部を付き合わせ溶接する。



【図26】

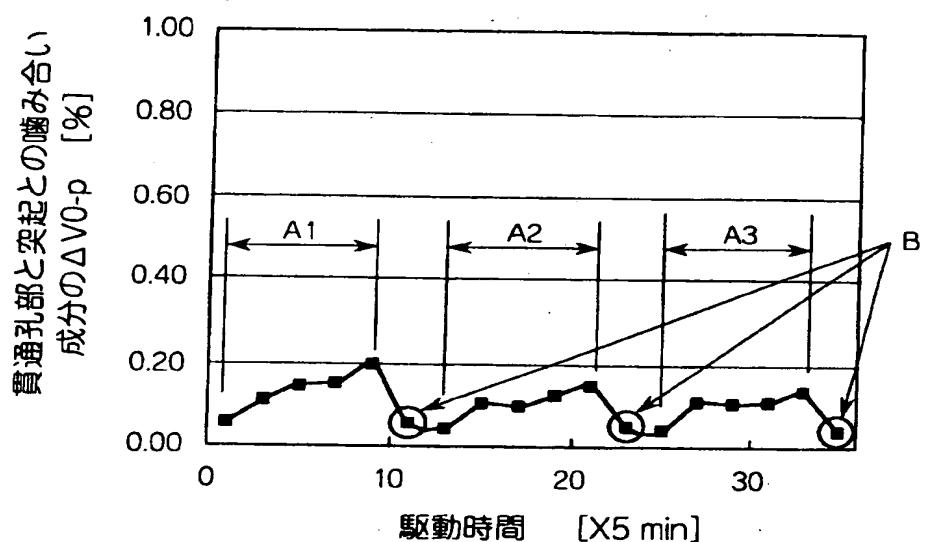


【図27】



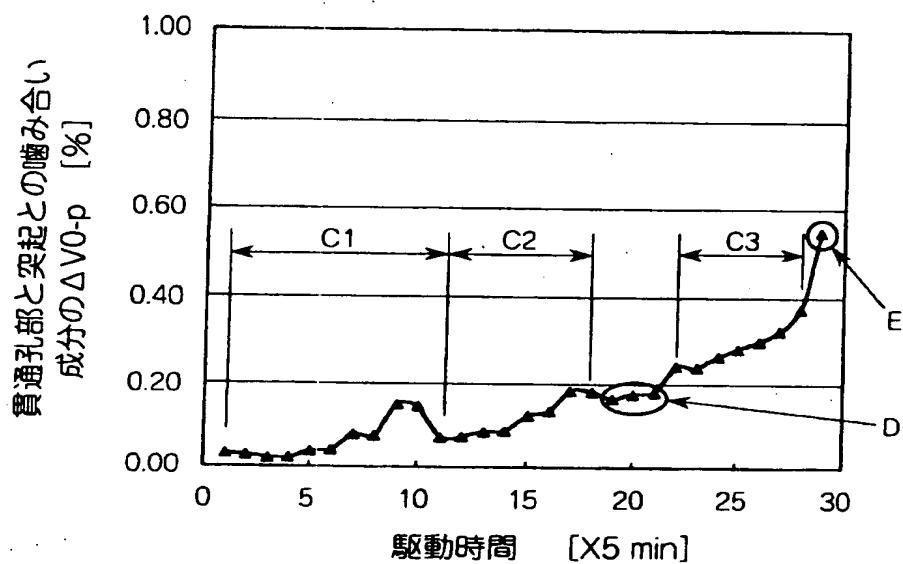
【図28】

実施例1における複数列孔タイプでの駆動結果

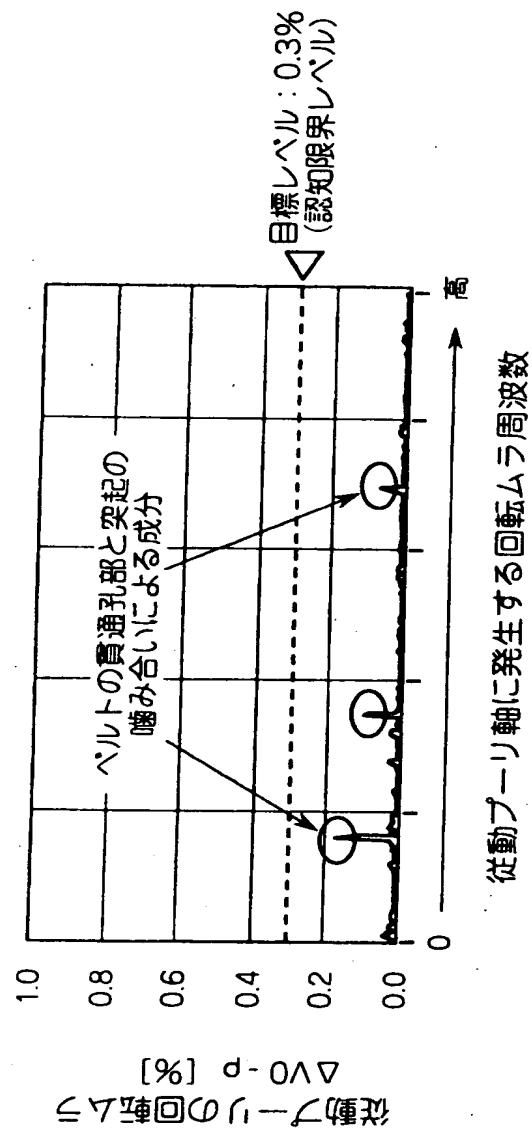


【図29】

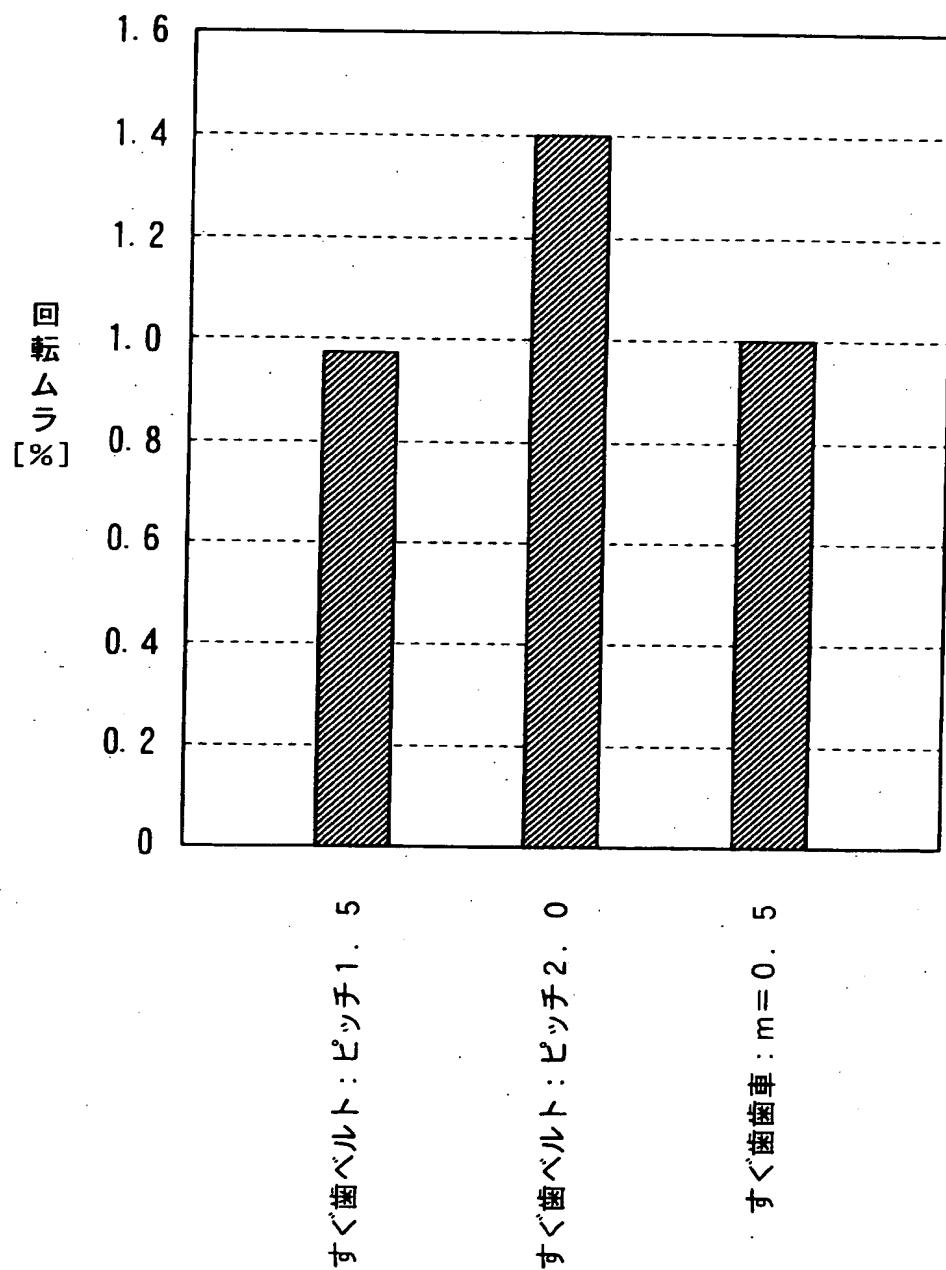
比較例(1列孔タイプ)での駆動結果



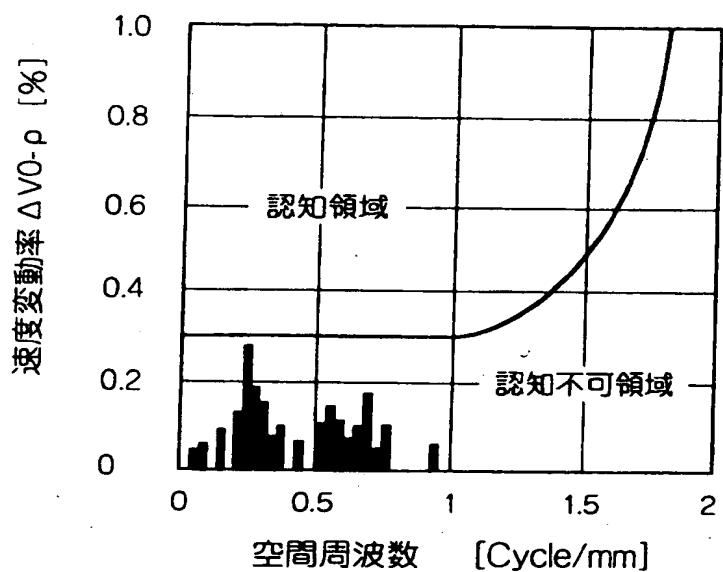
【図30】



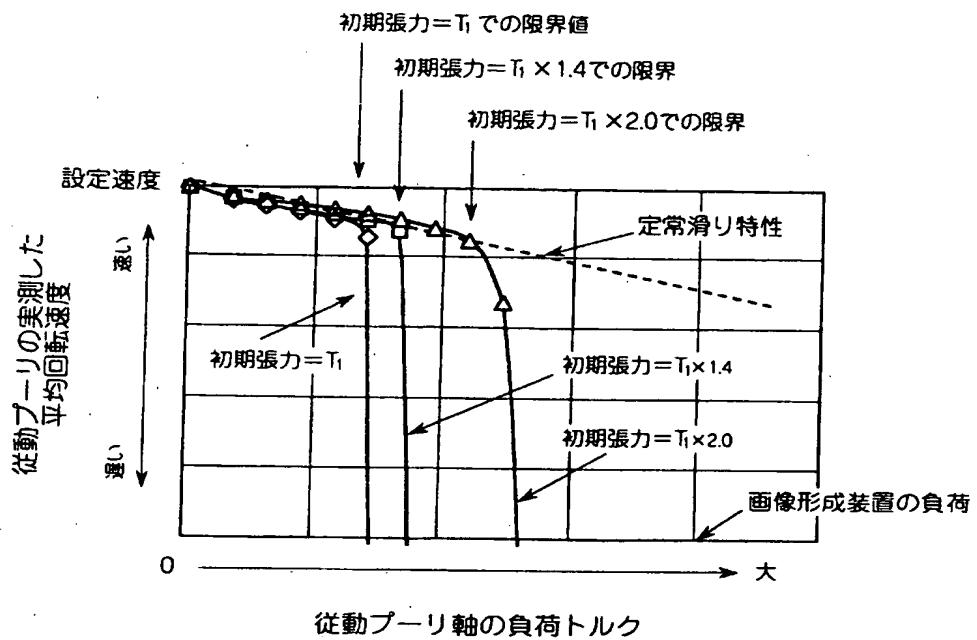
【図31】



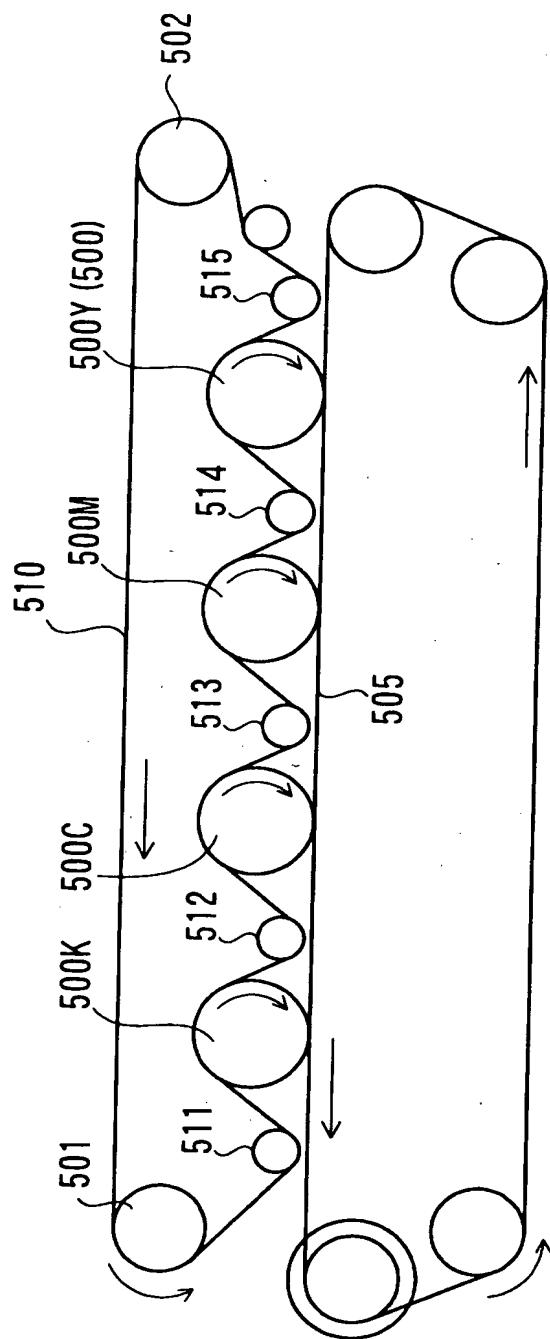
【図32】



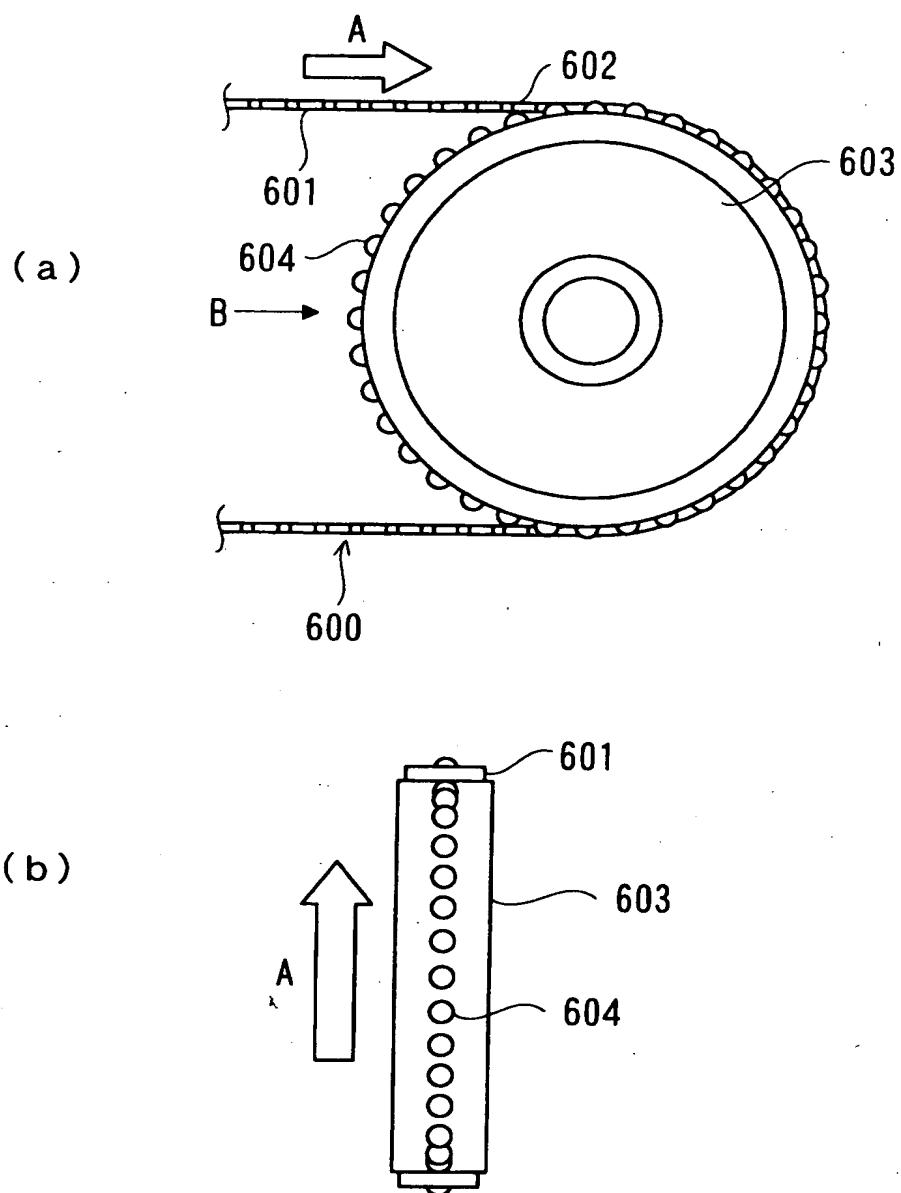
【図33】



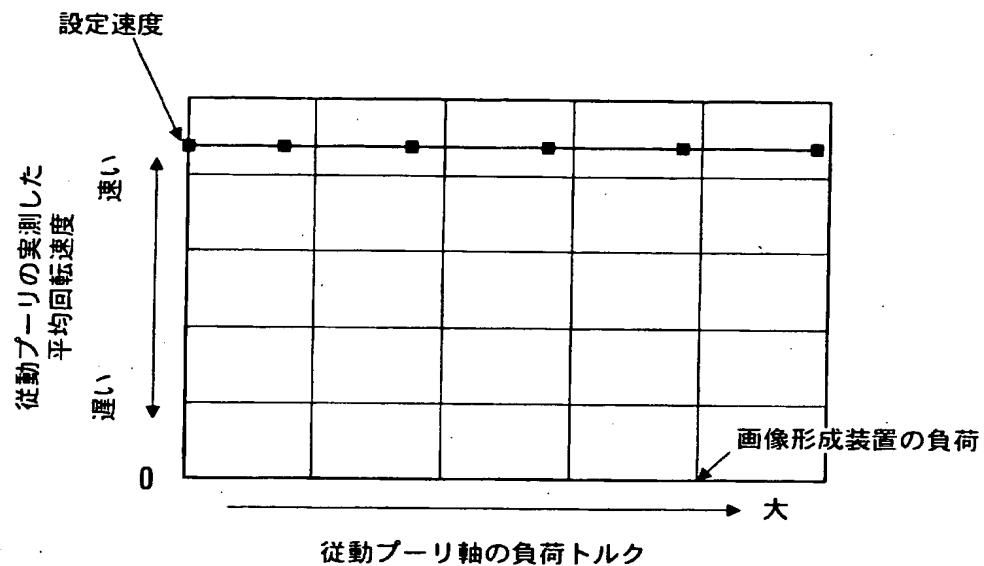
【図34】



【図35】



【図36】



【書類名】 要約書

【要約】

【課題】 複数の張架部材に無端状の平ベルトを掛け渡す態様において、ブーリ等の張架部材と平ベルトとの間の滑りによる駆動力の伝達誤差をなくし、被駆動体に大きな負荷が係る状態であっても、駆動力を安定的に伝達する。

【解決手段】 平ベルト1の少なくとも一つには平ベルト1の進行方向に沿って複数列の貫通孔3を設け、当該平ベルト1が掛け渡される張架部材2の少なくとも一つには平ベルト1の貫通孔3が嵌合する突起4を張架部材2の回転方向に沿って複数列設ける。また、駆動力が伝達せしめられる張架部材2の少なくとも一つ2aに当該張架部材2aの回転軸に対して同軸で且つ自由回転可能な自由回転体5を設け、この自由回転体5が設けられた張架部材2aとは異なって隣接し合う張架部材2b, 2cに対し平ベルト1を自由回転体5を介して掛け渡す（図3）。更に、これらの駆動力伝達装置を用いた画像形成装置をも対象とする。

【選択図】 図1

特2001-281921

出願人履歴情報

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Applicant(s): FUJI XEROX CO., LTD.

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(Seal)

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[Title of the Invention] DRIVING FORCE TRANSMISSION APPARATUS AND IMAGE FORMING APPARATUS USING THE SAME

[Number of Claim(s)] 15

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[Title of the Invention] DRIVING FORCE TRANSMISSION APPARATUS
AND IMAGE FORMING APPARATUS USING THE SAME

[Scope of the Invention]

5 [Claim 1] A driving force transmission apparatus for
transmitting a driving force by wearing one or plural an
endless-shaped flat belts on plural tension members,

the driving force transmission apparatus characterized
in that plural through holes are formed in at least one of
10 the flat belts along a travel direction of the at least one
of the flat belts; and that at least one of the tension members
over which said flat belt is worn is formed plural columns
of projections engaging with the through holes of the flat
belt along a rotation direction of said tension member.

15 [Claim 2] The driving force transmission apparatus
according to claim1,

the driving force transmission apparatus characterized
in that the through holes adjacent to each other in a width
direction perpendicular to the travel direction of the flat
20 belt are arranged at positions where the through holes are
not overlapped with each other in the travel direction of the
flat belt.

[Claim 3] An image forming apparatus comprising a drive
source for producing driving force; an image carrier driven
25 by said driving force from the drive source; and a driving

force transmission apparatus for transmitting the driving force produced by said drive source to said image carrier,

the image forming apparatus characterized in that said driving force transmission apparatus comprises a plurality 5 of tension member disposed between the drive source and the image carrier; and one or a plurality of endless-shaped flat belts worn over the plurality of tension members, and

that plural through holes are formed in at least one of the flat belts along a travel direction of the at least one 10 of the flat belts; and that at least one of the tension members over which said flat belt is worn is formed plural columns of projections engaging with the through holes of the flat belt along a rotation direction of said tension member.

[Claim 4] A driving force transmission apparatus for 15 transmitting a driving force by wearing one or plural an endless-shaped flat belts on plural tension members,

the driving force transmission apparatus characterized in that a free rotating member is formed on at least one of the tension members to be transmitted the driving force, the 20 free rotating member having the same axis as a rotation axis of the at least one of the tension members and being freely rotatable, and that the flat belts are worn over adjacent tension members different from the tension member formed the free rotating member through the free rotating member.

25 [Claim 5] The driving force transmission apparatus

according to claim 4,

the driving force transmission apparatus characterized in that plural through holes are formed in at least one of the flat belts along a travel direction of the at least one of the flat belts; and that at least one of the tension members over which said flat belt is worn is formed plural columns of projections engaging with the through holes of the flat belt.

[Claim 6] The driving force transmission apparatus according to claim 4,

the driving force transmission apparatus characterized in that the free rotating member is positionally restricted by a position restriction member with respect to an axial direction of the rotation axis of the tension member.

[Claim 7] The driving force transmission apparatus according to claim 4,

the driving force transmission apparatus characterized in that the free rotating member includes a position regulation portion for restricting a position thereof with respect to a width direction perpendicular to the travel direction of the flat belt worn thereover.

[Claim 8] An image forming apparatus comprising a drive source for producing driving force; an image carrier driven by said driving force from the drive source; and a driving force transmission apparatus for transmitting the driving force

produced by said drive source to said image carrier,

the image forming apparatus characterized in that said driving force transmission apparatus comprises a plurality of tension member disposed between the drive source and the 5 image carrier; and one or a plurality of endless-shaped flat belts worn over the plurality of tension members, and

that a free rotating member is formed on at least one of the tension members to be transmitted the driving force, the free rotating member having the same axis as a rotation 10 axis of the at least one of the tension members and being freely rotatable, and that the flat belts are worn over adjacent tension members different from the tension member formed the free rotating member through the free rotating member.

[Claim 9] A driving force transmission apparatus for 15 transmitting a driving force by wearing one or plural an endless-shaped flat belts on plural tension members,

the driving force transmission apparatus characterized in that elongated-hole shaped through holes are formed on at least one of the flat belts and are elongated along a width 20 direction perpendicular to a travel direction of the flat belt; and that at least one of the tension members over which said flat belt is worn is formed a pillar-shaped projection engaging with the elongated-hole shaped through holes of the flat belt along a rotation direction of said tension member.

25 [Claim 10] An image forming apparatus comprising a drive

source for producing driving force; an image carrier driven by said driving force from the drive source; and a driving force transmission apparatus for transmitting the driving force produced by said drive source to said image carrier,

5 the image forming apparatus characterized in that said driving force transmission apparatus comprises a plurality of tension member disposed between the drive source and the image carrier; and one or a plurality of endless-shaped flat belts worn over the plurality of tension members, and

10 that elongated-hole shaped through holes are formed on at least one of the flat belts and are elongated along a width direction perpendicular to a travel direction of the flat belt; and that at least one of the tension members over which said flat belt is worn is formed a pillar-shaped projection engaging 15 with the elongated-hole shaped through holes of the flat belt along a rotation direction of said tension member.

[Claim 11] The driving force transmission apparatus according to claim 9, wherein the at least one of the flat belts is formed an elongated-hole shaped through hole or both 20 an elongated-hole shaped through hole and a circle-shaped through hole; and the at least one of the tension members is formed a pillar-shaped projection engaging with the elongated-hole shaped through hole and a semi-spherical shaped projections engaging with the elongated-hole shaped through hole or the 25 circle-shaped through hole,

the driving force transmission apparatus characterized in that a relation of $d_1 \leq d_2 \leq d_3$ is satisfied where d_1 denotes a gap between an edge portion of the pillar-shaped projection and that of the elongated-hole shaped through hole in the travel direction of the flat belt, d_2 denotes a gap between an edge portion of the pillar-shaped projection and that of the elongated-hole shaped through hole in the width direction of the flat belt, and d_3 denotes a gap between an edge portion of the semi-spherical shaped projections and that of the pillar-shaped projection or that the elongated-hole shaped through hole in the width direction of the flat belt

[Claim 12] An image forming apparatus comprising a drive source for producing driving force; an image carrier driven by said driving force from the drive source; and a driving force transmission apparatus for transmitting the driving force produced by said drive source to said image carrier,

the image forming apparatus characterized in that the driving force transmission apparatus includes plural tension members disposed between the drive source and the image carrier; and one or plural of endless-shaped flat belts worn over the plural tension members, and

that the driving force transmission apparatus according to claim 11 is used.

[Claim 13] The driving force transmission apparatus according to claim 1, 4, or 9,

the driving force transmission apparatus characterized in that the at least one of the flat belts includes plural belt members, which contain the same material or the substantially same material, and at least one portions of which 5 are fixed to each other, and the plurality of belt members are arranged to be independently extensible from each other

[Claim 14] An image forming apparatus comprising a drive source for producing driving force; plural systems of image carriers driven by said driving force from the drive source; 10 and a driving force transmission apparatus for transmitting the driving force produced by said drive source to said plural systems of image carriers,

the image forming apparatus characterized in that the driving force transmission apparatus according to claim 1, 15 4, or 9 is used as a driving force transmission apparatus for transmitting the driving force to the system of the image carrier which is applied to the highest load among the plural systems of the image carriers.

[Claim 15] An image forming apparatus according to claim 20 3, 8, or 10, the image forming apparatus comprising two systems of image carriers,

the image forming apparatus characterized in that the driving force transmission apparatus includes a first flat belt for transmitting the drive force to a first system of 25 the image carrier from one drive source and a second flat belt

for transmitting the drive force to a second system of the image carrier from the one drive source.

[Detailed Description of the Invention]

[0001]

5 [Technical Field to which the Invention belongs]

The present invention generally relates to a driving force transmission apparatus used in an image forming apparatus such as a copying machine, a printer, a facsimile, or a composite type machine made of these appliances. More specifically, 10 the present invention relates to an improvement in such a driving force transmission apparatus for transmitting driving force by wearing, or tensioning an endless flat belt on a plurality of tension members, and also relates to an improvement in an image forming apparatus with employment of this driving force 15 transmission apparatus.

[0002]

[Conventional Art]

Driving force transmission apparatus which are utilized in image forming apparatus such as a printer and a copying machine own such specific characteristics that structural 20 defects of these driving force transmission apparatus may directly induce image defects. Under such a circumstance, various sorts and higher requirements such as high engaging rates, high transmission rate, and suppression of rotation 25 fluctuations.

In order to realize the high engaging rates and the high transmission rates, or in order to achieve the better low rotation fluctuation performance as driving force transmission apparatus of image forming apparatus according to the related art, there
5 has been proposed a technique transmitting driving force to an image carrier by using helical gears (see, for instance, Japanese Laid-open Patent Applications No. Hei-9-80840, and No. Hei-5-72862).

Also, another technique using belts equipped with teeth
10 has been proposed as driving force transmission member since employment of the belts equipped with teeth can realize lower rotation fluctuation performance than the employment of the helical gear.

Furthermore, in order to realize a lower rotation
15 fluctuation than that realized by employing the belt equipped with teeth, another technique using a helical gear belt has been proposed (see, for example, Japanese Laid-open Patent Applications No. Hei-9-160332 and No. Hei-10-26903).

[0003]

20 In general, in the case that a helical gear is employed as a driving force transmission member, the engaging rate is made large easily, as compared with such a case that a spur gear is employed as this driving force transmission member, and also, a meshing between a drive gear and a driven gear
25 is carried out slowly. As a result, it can be found that meshing

vibrations which are transferred to this driven gear can be considerably reduced. However, in such a case that a gear is employed as such a driving force transmission member, such a technical problem cannot be avoided. Namely, rotation 5 fluctuations are produced by a back lash.

In other words, when the drive gear is meshed, or engaged with the driven gear so as to rotary-drive this driven gear, the teeth of the drive gear is mutually made in contact with the teeth of the driven gear only for a predetermined time duration. However, after this time duration elapses, the teeth 10 of the drive gear and the teeth of the driven gear are brought into non-contact states until the next teethes are meshed with each other, which implies a back lash (play). As a result, a back lash produces vibrations when the next teethes of these 15 drive/driven gears are engaged with each other, and the driven gear constitutes a factor by which periodic rotation fluctuations occur (namely, engagement between teethes of gears are repeated).

This back lash cannot be in principle avoided in the case that gears are used. In such a case that gears are employed 20 as a driving force transmission member of an image forming apparatus, a driven gear is vibrated by such a gear engagement to be easily moved only by a movement corresponding to a back lash under non-constraint state. As a result, even such a small vibration force caused by the engagement vibration causes 25 the periodic concentration (density) fluctuations to be produced

in an output image.

[0004]

Also, even when a helical gear is employed, a total number of meshed teeth cannot be largely increased, as compared with 5 such a case that a spur gear is used. As a consequence, when a deformation problem as to teeth is considered, the helical gear is required to be manufactured by using such a material having a certain high hardness especially in a meshing contact portion thereof.

10 However, in such a case that a drive gear made of a material having a high hardness is engaged with a driven gear made of a material having a high hardness, since a portion capable of absorbing vibrations produced by this gear engagement is not present in a driving force transmission path (namely, within 15 transmission path in case that several rotating members are driven by gear train), meshing vibrations which are produced by meshing the drive gear with the driven gear are not attenuated, but are directly transferred to the driven gear. As a result, there is another technical problem that periodic concentration 20 fluctuations are produced in an output image.

[0005]

On the other hand, in a driving force transmission apparatus with employment of a belt equipped with teeth, since the belt equipped with the teeth which is meshed with a pulley is made 25 of such a material as a rubber material having superior

flexibility, it is so expected that vibrations produced by engaging the pulley with the belt equipped with the teeth are smaller than those produced by the gears. However, as a result of the actual measurement, there is substantially no difference 5 between the vibrations produced by the belt equipped with the teeth and the gears, as explained as follows:

That is to say, Fig. 31 is a diagram for representing rotation fluctuations in case that both a spur gear belt and a spur gear are employed as a driving force transmission member.

10 As apparent from Fig. 31, even when the spur gear belt is employed, rotation fluctuation results thereof are obtained which are not different from those of the spur gear.

Apparently, a rotation fluctuation can be improved by narrowing a pitch of teeth. However, when this pitch of the 15 teeth is excessively narrowed, a so-called "teeth skipping phenomenon" caused by an increased load occurs, so that gears cannot be actually driven. Therefore, a great improvement could not be expected. As a result, even when the spur gear belt is employed, it is impossible to avoid an occurrence of 20 concentration fluctuations in an output image.

[0006]

Fig. 32 represents a relationship between a concentration fluctuation allowable value and a rotation fluctuation of an image carrier drum in an image forming apparatus such as a 25 printer.

In this drawing, such a rotation fluctuation level of the image carrier drum, at which a concentration fluctuation contained in an output image can be recognized, is equal to approximately 0.3 % in a speed variation rate of ΔV_0-p (%) 5 which constitutes an index of such a rotation fluctuation. When such a speed variation rate larger than, or equal to this fluctuation level occurs, there is a problem as to concentration fluctuations of the output image. As a consequence, the engaging vibration levels produced in the gears and the belt equipped 10 with the teeth constitute a very serious problem in view of this concentration (density) fluctuation.

In other words, as to the rotation fluctuation requirement as the image forming apparatus, very high levels are required. Even when a helical gear belt is employed, a so-called "teeth 15 skipping phenomenon" occurs in a similar manner to that of the spur gear belt. It is practically difficult to achieve such an improvement that the rotation fluctuation level of the spur gear belt shown in Fig. 31 is reduced lower than, or equal to the allowable value.

20 [0007]

As a consequence, as the techniques according to the related arts capable of solving such a technical problem, for instance, the following driving force transmission apparatus has already been proposed (see, for instance, Japanese Laid-open Patent 25 Application No. Hei-7-319254). That is, as a driving force

transmission apparatus for moving outer peripheral planes of a plurality of image carrier drums by the same move amounts, respectively, an endless-shaped flat belt is worn between a drive pulley and a driven pulley in order to transfer the driving force.

In this type of driving force transmission apparatus, since the driving force is transferred between the flat belt and the pulley (drive pulley and driven pulley) by way of friction force, in principle, such meshing vibrations which are produced by meshing the gear with the belt equipped with the gear are not produced between the flat belt and the pulley. As a result, this technique according to the related art can effectively prevent the periodic concentration fluctuation from being produced in the output image, which occurs in such a case that the gear and the belt equipped with the gear are employed.

[0008]

[Problem to be Solved by the Invention]

However, in this sort of driving force transmission apparatus according to the related art using the flat belt, since the driving force transmission between the flat belt and the pulley is realized by utilizing the friction transmission, another technical problem newly occurs, namely, a slip occurs between the flat belt and the pulley.

In this case, Fig. 33 is a graph indicating a relationship between an average rotation speed of a driven pulley and load

torque in a driving force transmission apparatus with employment of a flat belt.

As indicated in Fig. 33, the average rotation speed of the driven pulley is rapidly lowered when the load torque exceeds 5 a limit value. This reason is given as follows: That is, while the normal slip amount is similarly increased in connection with an increase in the load given to the driven pulley shaft (namely, driven shaft), when the load becomes larger than, or equal to a certain limit value, the slip between the flat 10 belt and the drive pulley, or the slip between the flat belt and the driven pulley is rapidly increased, so that the average rotation speed of the driven pulley is largely lowered.

[0009]

When the driving force is transferred in the vicinity 15 of the load amount of the driven pulley shaft under such a condition, the speed of this driven pulley is brought into unstable condition while time has passed. As a result, color shifts (color deviation) and/or transfer fluctuations occur in an output image, so that the normal image forming operation 20 cannot be carried out. In the worst case, the image forming apparatus is stopped or malfunctions.

Also, in order to improve the limit value of the load torque, it is advantageous to increase the belt initial tension.

In other words, since the belt initial tension is increased, 25 depression force used to depress the belt against the pulley

is increased. As a result, since the friction driving force is increased, the limit value of this load torque is increased.

However, in such a case that a rubber belt and/or a resin belt is employed, rigidity of the belt itself is low, and thus, 5 high tension cannot be applied thereto. As a result, the use of metal belts may be conceived in order to secure rigidity of a driving force transmission system and also to obtain stable driving force. However, since a friction coefficient between such a metal belt and a pulley is extremely smaller than a 10 friction coefficient between either a rubber belt or a resin belt and a pulley, as represented in Fig. 33, a limit value of a load given to a driven pulley shaft cannot be largely improved. Even when doubled tension was applied to these rubber and resin belts, these belts could not be driven by achieving 15 a target load amount of an image forming apparatus.

[0010]

Also, in order that a limit value of load torque is improved by employing a metal belt, in such a case that very large belt initial tension is applied to this metal belt, shafts for 20 supporting pulleys are flexed. As a result, the alignment of the respective pulley shafts is shifted, and the metal belt is largely meandered. Accordingly, since the flat belt was rubbed under large force with respect to the belt edge guides provided on the pulleys, distortions were produced in belt 25 edge portions, so that the flat belt was driven under unstable

condition.

As a consequence, under such a driven load condition predictable in an actual image forming apparatus, there is fatal defect, for instance, stable image forming operation 5 cannot be realized. This metal belt employment could not also constitute the satisfactory solution.

[0011]

Furthermore, a winding angle of a belt to a pulley is increased, and whereby belt depression force given to the pulley 10 by tension can be increased. As a result, increasing of the belt winding angle to the pulley is effective with respect to a slip of a belt.

For instance, as indicated in Fig. 34, the following technique has already been proposed, i.e., while a driving 15 pulley (not shown) is provided in a coaxial manner with respect to a plurality of photosensitive drums 500 (500Y, 500M, 500C, 500K) as a driving force transmission apparatus for the plural photosensitive drums, a flat belt 510 is wound on this driving pulley. In addition to both a drive tension pulley 501 and 20 a driven tension pulley 502, several pieces of auxiliary tension pulleys 511 to 515 are provided, so that the winding angle of the flat belt 510 with respect to such a pulley for driving the photosensitive drums 500 can be secured to be large (for example, see Japanese Laid-open Patent Applications No. 25 Hei-7-319254, No. Hei-10-111586, and No. Hei-10-161384).

Incidentally, in Fig. 34, a reference numeral 505 denotes a belt unit used in an intermediate transfer operation, or used to transport paper.

However, in this type of driving force transmission
5 apparatus, a large space is necessarily required so as to tension the belt (flat belt 510), and also, the supporting members for supporting the auxiliary tension pulleys 511 to 515 are necessarily provided. Such an arrangement is not preferably employed in view of compact/low cost aspects.

10 [0012]

Under such a circumstance, the Inventors of the present invention have considered such an embodiment with employment of a so-called perforation belt as a driving force transmission apparatus for, e.g., image carrier drums of a color image forming
15 apparatus.

Figs. 35A and 35B show an outline of a driving force transmission apparatus with employment of a perforation belt. That is, a perforation belt 600 (Concretely speaking, a flat belt 601 in which through holes 602 are arranged in a predetermined pitch interval along a circulation move direction (namely, flat belt having holes)) is worn over either a drive pulley 603 or a driven pulley 603. Projections 604 corresponding to these through holes 602 are formed on an outer peripheral plane of this pulley 603. Then, while the projections 604 of the pulley 603 are fitted to the through holes 602 of the

flat belt 601, this perforation belt 600 is moved in a circulation manner.

[0013]

In such a type of driving force transmission apparatus,
5 in comparison with the driving force transmission mode using
the gear and also the belt equipped with the gear according
to the related arts, respectively, there is no back lash occurred
when the through holes are engaged with the projections (even
when clearances are present in the through holes and the
10 projections, since the belt itself is wound on the pulley,
the non-constraint condition does not occur). The vibrations
produced when the through holes are meshed with the projections
can be reduced. Therefore, it is possible to prevent image
defect such as periodic concentration fluctuation from occurring
15 in the output image.

Also, the driving force is transferred by mutually engaging
the projections 604 of each of the pulleys 603 with the through
holes 602 of the flat belt 601. As a consequence, even when
a heavy load is applied, both the flat belt and the pulleys
20 do not slip with each other, as compared with the case according
to the related art that the driving force is transferred by
using friction force exerted between the flat belt and the
pulley. Therefore, it is possible to avoid an occurrence of
an image defect, for example, a color shift, or color deviation,
25 and/or an image transfer fluctuation occurs in an output image.

Fig. 36 represents a relationship between a load given to a driven pulley and an average rotation speed of the driven pulley in a driving force transmission apparatus using a perforation belt.

5 As understood from this drawing, since the driving force is transferred by way of the perforation belt (namely, flat belt equipped with holes), under a state that a higher load than that of the normal flat belt is applied to this perforation belt, there is no risk that the average rotation speed is lowered
10 due to slips.

[0014]

Also, when a driving force transmission apparatus using such a perforation belt is employed, a utility possibility of a material which is used as a flat belt and a pulley can be extended. In other words, in case that the driving force is transferred by using the friction force exerted between the flat belt and the pulley in the driving force transmission apparatus according to the related art, such a material having a higher friction coefficient (for example, resin material)
15 must be necessarily employed. It is essentially impossible to use any materials having low friction coefficients (for instance, metal materials).
20

However, in this embodiment using such a perforation belt, since the driving force is transferred by mutually engaging
25 the projections 604 of the respective pulleys 603 with the

through holes 602 of the flat belt 601, more proper materials can be selected irrespective of magnitudes of friction factors.

[0015]

However, in this driving force transmission apparatus
5 with employment of the perforation belt, the slips which are produced in the embodiment using the normal belt are prevented by engaging the through holes of the flat belt with the projections formed on the pulleys. As a result, when the heavy load torque is applied to the driven pulley shafts, the force executed
10 in the engagement between the through holes and the projections is increased. If the thickness of this perforation belt is thin, then distortions of the through holes are increased. Therefore, there is such a phenomenon that either the hole portions of the thorough holes or the projections are destroyed.
15 Normally, since rigid balls are used in projection portions, destruction occurs in hole portions of through holes of the perforation belt.

In this case, in order to avoid destruction of through holes formed in a perforation belt, the following measures
20 may be conceived. That is, a tensile load of the perforation belt is decreased by enlarging a diameter of a pulley; a thickness of this perforation belt is made thicker; and since pitch intervals of through holes and also of projections formed on the pulley are narrowed, a total number of engagements in a
25 region where the perforation belt is wound on both a drive

pulley and a driven pulley is increased.

[0016]

However, in such a case that this sort of driving force transmission apparatus is applied to color image forming apparatus and the like, which are available in recent year, since these color image forming apparatus are progressively made compact in current year, diameters of pulleys cannot be extremely increased. In connection with this technical aspect, the following technical problem occurs. That is, when the thickness of this perforation belt is made thicker, rigidity of this perforation belt is increased, so that the perforation belt cannot be wound on the pulleys having the small diameters.

Also, when the intervals of the through holes and also of the projections are gradually made narrow, the distortions occurred in the respective through holes cannot be absorbed among these through holes. As a result, the hole portions of the through holes are destroyed.

Furthermore, this destruction of the through-hole portions is caused not only by the load torque of the driven pulley shafts, but also the belt meandering operations.

[0017]

In other words, in such a driving force transmission system by way of a perforation belt, since belt initial tension is increased similar to that of a flat belt, a load torque limit value of a driven pulley shaft can be improved. As a consequence,

it is preferable to apply belt tension having a certain magnitude to this perforation belt. However, since such belt tension is applied to this perforation belt, there is a shift in alignments of the respective pulley shafts, which would cause meandering operations of the perforation belt. Although the meandering operation of the flat belt is prevented by using the guides, in accordance with the driving force transmission system by way of the perforation belt, when the clearances between the hole portions of the through holes and the projections are increased larger than the necessary clearance value, this method gives not good effects with respect to the rotation fluctuations. As a result, generally speaking, it is practically difficult to provide guides on pulleys over which the perforation belt is worn.

As a consequence, similar to the load torque given to the driven pulley shaft, the hole portions of the through holes continuously receive the force along the meander direction also by the meandering operation of the belt while this perforation belt is driven. Since this force produced by the belt meandering operation is synthesized with force produced by the load torque along the belt rotation force, the hole portions of these through holes are brought into such a condition that these hole portions may be very easily destroyed. Further, the degrees of meandering operations are changed in response to a change in the belt tension caused by such a change in

the load torque, and whereby the destruction phenomenon occurs.

[0018]

The present invention has been made to solve the above-explained technical problems, and therefore, has an object 5 to provide a driving force transmission apparatus and an image forming apparatus with employment of this driving force transmission apparatus. That is to say, in such a driving force transmission apparatus in which an endless-shaped flat belt is worn over a plurality of tension members, while 10 eliminating a transmission error of driving force which is caused by slips produced among the endless-type flat belt and the tension members such as pulleys, the driving force can be transferred under stable condition even under such a condition that a heavy load is given to a member to be driven.

15 [0019]

[Means for Solving the Problem]

As shown in Fig. 1, the present invention is characterized in that in a driving force transmission apparatus for transferring driving force by wearing either one or a plurality 20 sets of endless-shaped flat belts 1 over a plurality of tension members 2 (for example, 2a to 2d), a plurality of columns of through holes 3 are formed in at least one of the flat belts 1 along a travel direction of the flat belts 1, a plurality of columns of projections 4 engaging with the through holes 25 3 are provided on at least one of tension members 2 over which

the flat belts 1 is worn along a rotation direction of the tension member 2.

Then, in Fig. 1, for example, when driving force derived from a drive source (not shown) is transferred to one tension member 2a, the driving force is transferred via this tension member 2a to the flat belt 1, and then, the driving force is transferred via this flat belt 1 to a member to be driven (not shown) which is provided in a coaxial manner to, for instance, tension members 2b and 2c.

10 [0020]

In such a technical means, as the endless-shaped flat belt 1, the present invention is not limited only to a single set of endless-shaped flat belt, but also to a plurality sets of endless-shaped flat belts.

15 Also, the tension member 2 may be selected from any member capable of tensioning the flat belt 1, and thus, may widely involve a pulley, a roller, and the like.

Furthermore, in view of stable transmissions of the driving force, rigidity of each of members which constitute the driving 20 force transmission apparatus is preferably selected to be high.

As a result, preferably, the above-described flat belt 1 and tension member 2 is manufactured by employing such a material having a high rigidity, for example, a metal material. As a proper sort of metal materials, stainless steel is preferably 25 employed in view of durability thereof.

Furthermore, in the flat belt 1, a plurality of through holes 3 are arrayed along a travel direction of this flat belt 1. Since the through holes 3 are fitted to the projections 4 which are formed on the rotating tension member 2, these 5 through holes 3 are provided in a predetermined pitch interval along the travel direction of this flat belt 1.

Shapes of the projections 4 and of the through holes 3 may be arbitrarily selected. Generally speaking, considering the fitting characteristics between both the projections 4 10 and the through holes 3, the shapes of the projections 4 are selected to be semi-spherical, whereas the shapes of the through holes 3 are selected to be circular.

[0021]

In particular, in accordance with the present invention, 15 a plurality of columns of the above-described through holes 3 formed in the flat belt 1 may be formed along the travel direction of the flat belt 1.

In this case, the expression "the plurality of columns of through holes are formed along the travel direction of the 20 flat belt 1" implies that the plurality of columns of these through holes 3 are arrayed with respect to a width direction perpendicular to the travel direction of the flat belt 1, and this array method may be arbitrarily selected.

As previously explained, when the plurality of columns 25 of these through holes 3 are provided, even when heavy load

torque is applied to shafts of the tension members 2 (for example, 2b and 2c) which are coupled to the member to be driven, the force may be received in a distribution manner by the plurality of columns of these through holes 3. Therefore, destruction 5 occurred in portions of the through holes 3 can be effectively prevented.

[0022]

Also, as to a preferable array of these through holes 3, such through holes 3 which are located adjacent to each 10 other with respect to the width direction perpendicular to the travel direction of the flat belt 1 is preferably arranged at such a position where these through holes 3 are not overlapped with each other with respect to the travel direction of the flat belt 1.

15 With this through-hole arrangement, the belt rigidity among the through holes 3 is secured, and whereby even when large tension is applied as the belt initial tension, the destruction occurred in the hole portions of the through hole 3 which is caused by the belt meandering operation can be 20 effectively prevented.

[0023]

Furthermore, when the invention related to the above-explained driving force transmission apparatus is applied to an image forming apparatus, the following image forming 25 apparatus is accomplished.

In other words, an image forming apparatus according to the present invention is an image forming apparatus having a drive source for generating driving force; an image carrier rotary-driven by receiving the driving force generated from the drive source; and a driving force transmission apparatus for transferring the driving force generated from the driving source to the image carrier, as shown in Fig. 1, the driving force transmission apparatus comprising a plurality of tension members 2 arranged between the drive source and the image carrier; and either one or a plurality of endless-shaped flat belts 1, which are worn over these plural tension members 2; wherein a plurality of columns of through holes 3 are formed in at least one of flat belts 1 along a travel direction of the flat belts 1; and a plurality of columns of projections 4 engaging with the through holes 3 are provided on at least one of tension members 2 over which the flat belt 1 is worn along a rotation direction of the tension member 2.

Here, as the image carrier, in addition to a photosensitive member, an intermediate transfer member and a sheet, such as paper, transport member are included. As modes of these image carrier members, in addition to a drum-shaped (cylindrical) member, an endless-type belt member is included.

[0024]

In accordance with such an image forming apparatus, in the case that the above-described driving force transmission

apparatus is applied as the image forming apparatus, in comparison with the driving force transmission mode according to the related art using the gear and the belt equipped with the gear, there is no vibration occurred when the through holes 5 are engaged with the projections and thus it is possible to prevent such a problem that an image defect such as periodic concentration (density) fluctuation occurs in the outputs image.

Also, the driving force is transferred by mutually engaging the projections 4 of each of the tension members 2 with the 10 through holes 3 of the flat belt 1. As a consequence, even when a heavy load is applied, both the flat belt and the pulleys do not slip, as compared with the related art in which the driving force is transferred by using friction force exerted between the flat belt and the pulley. Furthermore, even when 15 a larger load is given, there is no risk that the hole portions of the through holes 3 are not destroyed. Therefore, it is possible to prevent an occurrence of an image defect, for example, a color shift, or color deviation, and/or an image transfer fluctuation occur in an output image. Thus, the stable image 20 forming operation may be carried out.

[0025]

Moreover, in view of energy saving aspect and cost reduction aspect, there is such a trend that the rotation loads given to the image carriers are increased in the below-mentioned 25 cases: that is, not only such image carriers, but also rotation

members such as a transfer roller and an electrostatic charging roller are rotary-driven by a single drive source, while these rotation members are rotary-driven in contact with the image carriers; and in order to reduce a total number of components, 5 slide bearings are employed instead of roller bearings as to the bearings used for these image carriers and other rotation members. As a consequence, the present invention is preferably applied to such an image forming apparatus.

[0026]

10 Also, there are such image forming apparatus equipped with a plurality of systems of image carriers among image forming apparatus.

In this case, in order to avail merits of the present invention, that is, even when the rotation load is large, no 15 slip occurs between the flat belt 1 and the tension members 2 such as the pulleys; the destruction of the hole portions of the through holes 3 formed in the flat belt 1 can be prevented; and no image defect is produced, for example, neither color shifts, nor transfer fluctuations occur in output images, the 20 present invention is preferably applied to the plurality of systems of image carriers to which heavier rotation loads are applied.

In such a case, an image forming apparatus of the present invention is realized by such an image forming apparatus 25 comprising: a drive force for generating driving force; an

image carrier rotary-driven by receiving the driving force generated from the drive source; and a driving force transmission apparatus for transferring the driving force generated from the driving source to the image carrier, the driving force transmission apparatus shown in Fig. 1 may be employed as such a driving force transmission apparatus capable of transferring the driving force to a system of an image carrier, in which the largest rotation load is applied, among plural systems of image carriers.

In this embodiment, the expression "driving force transmission apparatus capable of transferring driving force to system of image carrier, the rotation load of which is the largest load" implies such a driving force transmission system provided for a subject image carrier in such an assumption that there are plural image carriers belonging to a certain system, and driving force transmission systems for the respective image carriers are provided in a parallel manner. Also, this "driving force transmission apparatus" implies an entire driving force transmission system for a plurality of image carriers which contain such an image carrier having the largest rotation load in such an assumption that there are plural image carriers belonging to a certain system, and driving force transmission systems for the respective image carriers are provided in a series manner.

Furthermore, in such a case that a plurality of systems of image carriers are rotary-driven by a single drive source, there is such a risk that disturbance applied to one system of image carriers may give an influence to another image carrier.

5 As this disturbance, the following cases are conceivable. For instance, a cleaning apparatus is made in contact with a transfer apparatus, and/or is separated from this transfer apparatus, and an article rides over a recording sheet, and/or ride down this recording sheet.

10 In such a case, in an image forming apparatus equipped with two systems of image carriers, according to the present invention, a driving force transmission apparatus may comprise: a first flat belt for transferring driving force from one drive source to a first system of an image carrier; and a second
15 flat belt for transferring driving force from one drive source to a second system of an image carrier.

Since the image forming apparatus is configured in such a manner, even in a case that certain disturbance is applied to the first system of the image carrier and then this disturbance
20 is transferred via the first flat belt to the drive source, the drive source may cancel this disturbance based upon its characteristic, so that this disturbance is not transferred via the second flat belt to the second system of the image carrier. As to this characteristic of the drive source,
25 concretely speaking, while the drive source produces the drive

torque (namely, summation of load torque applied to both first flat belt and second flat belt) from the own drive source to rotate, the disturbance is penetrated through a large DC torque generating source, by which an adverse influence with respect
5 to this disturbance may become small, rather than such a case that a driven pulley directly receives disturbance (torque variation) from a flat belt, since the holding power of the drive source is made effective. Conversely, when the disturbance is applied to the second system of the image carrier,
10 a similar effect may be achieved.

[0028]

In this case, various embodiments may be conceived as to a relationship of two systems of image carriers: That is, for example, 1) the first system of the image carrier directly
15 contacts with the recording sheet, but the second system of the image carrier does not directly contact with this recording sheet; 2) a color of a toner image held on the image carrier surface belonging to the first system is different from a color of a toner image held on the image carrier surface belonging
20 to the second system; 3) the cleaning apparatus does not abut, but also is not separated from the first system of the image carrier, whereas the cleaning apparatus abuts, and is separated from the second system of the image carrier; 4) the transfer apparatus does not abut, but also is not separated from the
25 first system of the image carrier, whereas the transfer apparatus

abuts, and is separated from the second system of the image carrier; and also 5) both the cleaning apparatus and the transfer apparatus abut and are separated from the first and second systems of these image carriers at different timing.

5 [0029]

Also, as illustrated in Fig. 2(a), a driving force transmission apparatus according to another mode of the present invention is featured by that in such a driving force transmission apparatus for transferring driving force by wearing either 10 one or a plurality of endless-shaped flat belts 1 over a plurality of tension members 2 (for example, 2a to 2d), elongated-hole shaped through holes 3a which are elongated along a width direction perpendicular to a travel direction of the flat belt 1 are formed in at least one of the flat belts 1 along the 15 travel direction of the flat belts 1; and pillar-shaped projections 4a are formed on at least one of tension members over which the flat belt 1 is worn along a rotation direction of the tension member 2, the pillar-shaped projections 4a being fitted to the elongated-hole shaped through holes 3a of the 20 flat belt 1, and further, being elongated along a width direction perpendicular to the rotation direction of the tension member 2.

[0030]

In such a technical means, materials of the flat belt 25 1 and the tension member 2 are similar to those of the

above-described mode shown in Fig. 1.

Also, the flat belt 1 has the elongated-hole shaped through holes 3a arranged along the travel direction. Since the respective through holes 3a are employed so as to be fitted 5 to the pillar-shaped projections 4a formed on the rotating tension member 2, these through holes 3a are provided in a predetermined pitch interval along the travel direction of the flat belt 1.

In this case, normally, the shape of the elongated-hole 10 shape through hole 3a owns a straight line portion along the longitudinal direction thereof, but also has a curved line portion.

On the other hand, normally, the shape of the pillar-shaped projection 4a is a semi-circular cylinder shape, but is not 15 limited to this shape if the engaging/detaching operations thereof with respect to this elongated-hole shaped through hole 3a may be carried out in a smooth manner.

Furthermore, this mode may cover all of driving force transmission apparatus comprising the elongated-hole shaped 20 through holes 3a and the pillar-shaped projections 4a.

Alternatively, this mode may involve such driving force transmission apparatus in which circular-shaped through holes 3b (for example, see Fig. 2b) other than the elongated-hole shaped through holes 3a are provided, or semi-spherical shaped 25 projections 4b (for example, see Fig. 2b) other than the

pillar-shaped projections 4a are provided.

[0031]

As previously described, if the elongated-hole shaped through holes 3a are provided, even when the large load torque 5 is applied to the shafts of the tension members 2 (for example, 2b, 2c) which are coupled to the member to be driven, then the engaging (meshing) manner between the elongated-hole shaped through holes 3a of the flat belt 1 and the pillar-shaped projections 4a of the tension members 2 is not equal to such 10 a point contact of circles having different diameters (namely, circular through-holes and semi-spherical shaped projections), but is equal to a linear contact portion. That is, the driving force may be distributed to be received by this linear contact portion established between the longitudinal line-shaped 15 portion (either a straight line portion or a curved line portion) of the elongated-hole shaped through hole 3a, and the line-shaped portion of the pillar-shaped projection 4a formed on the tension member 2. As a result, the destruction occurred in the hole portions of the elongated-hole shaped through holes 3a can 20 be effectively prevented.

[0032]

Furthermore, when the inventive idea related to the above-explained driving force transmission apparatus is applied to an image forming apparatus, the following image forming 25 apparatus may be accomplished.

In other words, an image forming apparatus, according to the present invention, is featured by such an image forming apparatus comprising: a drive source for generating driving force; an image carrier rotary-driven by receiving the driving force generated from the drive source; and a driving force transmission apparatus for transferring the driving force generated from the driving source to the image carrier, as represented in Fig. 2(a), in which: the driving force transmission apparatus is comprised of: a plurality of tension members 2 arranged between the drive source and the image carrier; and either one or a plurality of endless-shaped flat belts 1, which are worn over these plural tension members 3; elongated-hole shaped through holes 3a which are elongated along a width direction perpendicular to a travel direction of the flat belt 1 are formed in at least one of the flat belts 1 along the travel direction of the flat belt 1; and pillar-shaped projections 4a which are fitted to the elongated-hole shaped through holes 3a of the flat belt 1 and also are elongated along a width direction perpendicular to a rotation direction of the tension member 2 are provided on at least one of the tension members 2 over which the flat belt 1 is worn along the rotation direction of the tension member 2.

In this case, as the image carrier, a photosensitive member, and also a sheet transport member such as an intermediate transfer member and paper may be included. As modes of these image

carrier members, drum-shaped (cylindrical) members and endless-type belt members may be included.

Also, in accordance with this mode, similar operation and effects to those of the mode indicated in Fig. 1 may be
5 achieved.

[0033]

Also, as shown in Fig. 2(a) and Fig. 2(b), there is the following mode within the driving force transmission apparatus of this mode: That is, at least one of the flat belts 1 owns
10 either the elongated-hole shaped through holes 3a or both the elongated-hole shaped through holes 3a and the circular-shaped through holes 3b, whereas at least one of the tension members 2 owns both the pillar-shaped projections 4a and the semi-spherical shaped projections 4b. The pillar-shaped
15 projections 4a are fitted to the elongated-hole shaped through holes 3a, whereas the semi-spherical shaped projections 4b are fitted to either the elongated-hole shaped through holes 3a or the circular-shaped through holes 3b.

At this time, in the mode in which the circular-shaped
20 through holes 3b are provided, these circular-shaped through holes 3b are provided in a predetermined pitch interval, and the semi-spherical shaped projections 4b may be provided in correspondence with these circular-shaped through holes 3b.

In this case, as to the layouts between the pillar-shaped
25 projections 4a and the semi-spherical shaped projections 4b,

any properly-selected projection layouts may be employed, for example, every one projection may be formed, or every two projections may be formed with respect to the corresponding through holes. As to the quantities of these projections 4a and 4b, total numbers of both the projections 4a and 4b are not always equal to each other, but may be distributed based upon a proper distribution ratio.

[0034]

Moreover, in the mode in which the circular-shaped through holes 3b are not provided, the semi-spherical shaped projections 4b are fitted to the elongated-hole shape through holes 3a. In this case, although the shapes of the elongated-hole shaped through holes 3a which are fitted to both the pillar-shaped projections 4a and the semi-spherical shaped projections 4b may be made different from those of the projections 4a/4b, it is preferable to employ such elongated-hole shaped through holes 3a having the same structure when considering such a technical point that the structure of the flat belt 1 may be simplified.

Also, normally, one pair of semi-spherical shaped projections 4b which are fitted to the elongated-shaped through holes 3a are provided on both sides of the elongated-hole shaped through holes 3 along the longitudinal direction. However, the present invention is not limited to this structure. For example, 3, or more sets of semi-spherical shaped projections

4b may be formed.

[0035]

In such a mode, as represented in Fig. 2(a) and Fig. 2(b),
a relationship of " $d_1 \leq d_3 \leq d_2$ " may be preferably satisfied
5 based upon the following assumptions. That is, a space between
an edge portion of the pillar-shaped projection 4a and an edge
portion of the elongated-hole shaped through hole 3a along
the travel direction of the flat belt 1 is assumed as " d_1 ";
another space between an edge portion of the pillar-shaped
10 projection 4a and an edge portion of the elongated-hole shaped
through hole 3a along the width direction of the flat belt
1 is assumed as " d_2 "; and also, another space between an edge
portion of the semi-spherical shaped projection 4b and an edge
portion of either the elongated-hole shaped or the
15 circular-shaped through hole 3a, or 3b along the width direction
of the flat belt 1 is assumed as " d_3 ".

In this case, the pillar-shaped projections 4a may mainly
distribute the operation force with respect to the load torque
executed to the tension member 2, whereas the semi-spherical
20 shaped projections 4b may mainly restrict the positions with
respect to the meander direction of the flat belt 1.

As a result, while the meandering operation of the flat
belt 1 can be effectively avoided, the load torque can be
distributed and also the destruction of these through hole
25 portions (namely, elongated-hole shaped through holes 3a and

circular-shaped through holes 3b) can be prevented.

[0036]

Also, the present invention is directed to such an image forming apparatus into which such a driving force transmission apparatus capable of satisfying the above-explained relationship ($d_1 \leq d_3 \leq d_2$) is assembled.

In this case, the image forming apparatus of the present invention may be realized by such an image forming apparatus comprising: a drive source for generating driving force; an image carrier rotary-driven by receiving the driving force generated from the drive source; and a driving force transmission apparatus for transferring the driving force generated from the driving source to the image carrier, as represented in Fig. 2(a) and Fig. 2(b), in which: the driving force transmission apparatus is comprised of: a plurality of tension members 2 arranged between the drive source and the image carrier; and either one or a plurality of endless-shaped flat belts 1, which are worn over these plural tension members 3; and such a driving force transmission apparatus is capable of satisfying the above-explained relation ($d_1 \leq d_3 \leq d_2$).

[0037]

While there are some image forming apparatus equipped with plural systems of image carriers among these image forming apparatus, the inventive idea of the present invention may be preferably applied to such an image carrier belonging to

a system whose a rotation load is large, in a similar manner to the above-described image forming apparatus into which the driving force transmission apparatus shown in Fig. 1 is assembled.

5 In such a case, an image forming apparatus of the present invention may be realized by such an image forming apparatus comprising: a drive force for generating driving force; an image carrier rotary-driven by receiving the driving force generated from the drive source; and a driving force transmission apparatus for transferring the driving force generated from the driving source to the image carrier, the driving force transmission apparatus shown in Fig. 2 may be employed as such a driving force transmission apparatus capable of transferring the driving force to a system of an image carrier, in which
10 15 the largest rotation load is applied, among plural systems of image carriers.

Furthermore, in such a case that two systems of image carriers are rotary-driven by using a single drive source, an image forming apparatus equipped with two systems of image carriers, according to the present invention, is featured by that a driving force transmission apparatus may be comprised of: a first flat belt for transferring driving force from one drive source to a first system of an image carrier; and a second flat belt for transferring driving force from one drive source
20 25 to a second system of an image carrier.

[0038]

Also, a driving force transmission apparatus, according to an further aspect of the present invention, is featured by such a driving force transmission apparatus for transferring 5 driving force by wearing either one or a plurality of endless type flat belts 1 over a plurality of tension members 2 (for example, 2a to 2c), as indicated in Fig. 3, in which a free rotating member 5 is provided on at least one (for example 2a) of these tension members 2 to which the driving force is 10 transferred in such a manner that the free rotating member 5 is freely rotatable, and is arranged in a coaxial manner with respect to a rotation shaft of this tension member 2a; and the flat belt 1 is worn via the free rotating member 5 over tension members 2 (for example, 2b and 2c) which are different 15 from the tension member (for example, 2a) on which this free rotating member 5 is provided, and are located adjacent to each other.

[0039]

Then, in Fig. 3, when the driving force is transferred 20 to the tension member 2 (for example, 2a), the driving force is transferred via this tension member 2a to the flat belt 1, and then, the driving force is transferred via this flat belt 1 to a member to be driven (not shown) which is provided in a coaxial manner to, for example, the tension members 2b 25 and 2c.

At this time, since the flat belt 1 is worned via the free rotating member 5 with respect to the tension members 2b and 2c, the winding angle of this flat belt 1 with respect to the tension members 2b and 2a may be secured as a sufficiently 5 large winding angle, and also the friction resistance between this flat belt 1 and the tension members 2b/2c to which the driven member is coupled may become sufficiently high friction resistance. Thus, the driving force derived from the flat belt 1 may be firmly transferred to the tension members 2b 10 and 2c.

On the other hand, since the free rotating member 5 is freely rotatably provided on the rotation shaft of the tension member 2 (for example, 2a) in a coaxial manner, there is no necessity for especially securing the setting space of the 15 free rotating member 5.

As a consequence, the extra members for conventionally supporting the auxiliary tension pulley, and also the specific space are not required. Also, the winding angle of the flat belt 1 can be set to a sufficiently large winding angle with 20 respect to the tension members 2 (for example, 2b and 2c) to which the driving member is coupled.

[0040]

In such a technical means, as the flat belt 1, the present invention is not limited only to a single set of flat belt, 25 but also to plural sets of flat belts. Also, the tension member

2 may widely involve a pulley, a roller, and the like.

In this case, the expression "tension member 2 (for example, 2a) to which driving force is transferred" implies that the tension member 2 may be directly coupled to the drive source, 5 or the tension member 2 may be driven by another drive transmission system.

Furthermore, the expression "free rotating member 5" implies such a member which can be freely rotated and must be provided in a coaxial manner with respect to the rotation 10 shaft of the tension member 2 (for example, 2a) to which the drive force is transferred, and may widely involve a bearing, a collar, and the like.

[0041]

Also, in the mode shown in Fig. 3, the flat belt 1 may 15 involve the normal belt. Alternatively, in view of effectively avoiding the slip produced between the flat belt 1 and the tension member 2, the following modification mode may be preferably employed. That is, while either one column or plural columns of through holes (not shown) are formed in at least 20 one of flat belts 1 along a travel direction of this flat belt, projections (not shown) which are fitted to the through holes of the flat belt 1 are provided on at least one of tension members 2 over which this flat belt 1 is worn.

In accordance with such a modification mode, since the 25 winding angle of the flat belt 1 with respect to the tension

member 2 can be made large, the force which is exerted to the through-hole portions fitted to these projections can be distributed, and the destruction of these through hole portions can be effectively prevented.

5 [0042]

Furthermore, when the free rotating member 5 is moved along the rotation shaft direction of the tension member 2, since the flat belt 1 which is worn over this free rotating member 5 is meandered, it is preferable to restrict the position 10 of this free rotating member 5 along the shaft direction, in view of such a technical aspect that the meandering operation of the flat belt 1 is effectively prevented.

In this case, the free rotating member 5 may be positionally restricted by a position restriction member (not shown) with 15 respect to the shaft direction of the rotation shaft of the tension member 2.

Furthermore, even when the free rotating member 5 itself is positionally restricted along the shaft direction, there is such a risk that the flat belt 1 itself which is worn over 20 the free rotating member 5 is meandered. In view of such a technical aspect capable of effectively preventing the occurrence of such a belt meandering operation, it is preferable that a position of the free rotating member 5 is restricted in an axial direction.

25 The expression "position restricting portion" may widely

involve projections which are fitted to through holes if the flat belt 1 is equipped with the through holes, and also a restriction wall capable of preventing the meandering operation of the flat belt 1.

5 [0043]

Furthermore, when the inventive idea related to the above-explained driving force transmission apparatus is applied to an image forming apparatus, the following image forming apparatus may be accomplished.

10 In other words, an image forming apparatus, according to the present invention, is featured by such an image forming apparatus comprising: a drive source for generating driving force; an image carrier rotary-driven by receiving the driving force generated from the drive source; and a driving force transmission apparatus for transferring the driving force generated from the driving source to the image carrier, as represented in Fig. 4, in which: the driving force transmission apparatus is comprised of: a plurality of tension members 2 (for example, 2a to 2c) arranged between the drive source and 15 the image carrier; and either one or a plurality of endless-shaped flat belts 1, which are worn over these plural tension members. 20 3; a free rotating member 5 which is freely rotatable and is arranged in a coaxial manner with respect to a rotation shaft of one tension member (for example, 2a) among the tension members 25 2 is provided on at least one tension member 2a, to which the

driving force is transferred; and also the flat belt 1 is worn via the free rotating member 5 with respect to such tension members 2 (for example, 2b and 2c) which are located adjacent to each other, and are different from the tension member 2a
5 where this free rotating member 5 is provided.

[0044]

In accordance with such an image forming apparatus, the driving force transmission apparatus indicated in Fig. 3 can secure the large winding angle of the flat belt 1 with respect
10 to a plurality of tension members 2 without unnecessarily enlarging the layout space, and also can reduce the transmission error of the driving force. As a consequence, while this image forming apparatus can satisfy the requirements of compact/low cost aspects, it is possible to avoid an occurrence of an image
15 defect, for example, a color shift, or color deviation, and/or an image transfer fluctuation occurred in an output image. Thus, the stable image forming operation may be carried out.

Moreover, in view of energy saving aspect and also cost reduction aspect, there is such a trend that the rotation loads
20 given to the image carriers are increased in the below-mentioned cases: That is, not only such image carriers, but also rotation members such as a transfer roller and an electrostatic charging roller are rotary-driven by a single drive source, while these rotation members are rotary-driven in contact with the image
25 carriers; and in order to reduce a total number of components,

slide bearings are employed instead of roller bearings as to the bearings used for these image carriers and other rotation members. As a consequence, the inventive idea of the present invention may be preferably applied to such an image forming apparatus.

5 [0045]

Also, there are such image forming apparatus equipped with plural systems of image carriers among image forming apparatus. In this case, the inventive idea of the present invention may be preferably applied to plural systems of image carriers to which heavier rotation loads are applied similar to the image forming apparatus into which the driving force transmission apparatus shown in Fig. 1 has been assembled.

In such a case, an image forming apparatus of the present invention may be realized by such an image forming apparatus comprising: a drive force for generating driving force; an image carrier rotary-driven by receiving the driving force generated from the drive source; and a driving force transmission apparatus for transferring the driving force generated from the driving source to the image carrier, the driving force transmission apparatus shown in Fig. 3 may be employed as such a driving force transmission apparatus capable of transferring the driving force to a system of an image carrier, in which the largest rotation load is applied, among plural systems of image carriers.

Furthermore, in the case that two systems of image carriers are rotary-driven by a single drive source, an image forming apparatus, according to the present invention, may be realized by that in an image forming apparatus equipped with two systems 5 of image carriers, a driving force transmission apparatus may be comprised of: a first flat belt for transferring driving force from one drive source to a first system of an image carrier; and a second flat belt for transferring driving force from one drive source to a second system of an image carrier.

10 [0046]

In the driving force transmission apparatus and/or the image forming apparatus, normally, the structure of the flat belt 1 is constructed by one sheet of belt member. However, considering such technical aspects that the flat belts 1 may 15 be easily worn over the tension members 2 and further the destruction occurred in the hole portions of the respective through holes (3, 3a, 3b) may be more firmly prevented, at least one of flat belts 1 may be preferably formed as follows: That is, a plurality of belt members having either the same 20 materials or the substantially same material characteristics are superimposed with each other in such a manner that at least portions of these belt members are fixed, and furthermore, these belt members may be independently compressed/expanded.

In other words, the flat belt 1 of this embodiment is 25 wound on either the tension members 2 or the free rotating

member 5 in such a way that a plurality of belt members having the same materials, or the substantially same material characteristics (concretely speaking, tensile strength and bending strength) are superimposed with each other.

5 At this time, even when a plurality of belt members are superimposed with each other, the bending rigidity of this flat belt 1 is substantially equal to bending rigidity owned by one sheet of belt member, namely, small bending rigidity may be obtained. As a result, this flat belt 1 may be wound
10 on the tension members 2 and the free rotating member 5 under stable condition.

[0047]

Also, since the belt members having the same materials, or the substantially same material characteristics are
15 superimposed with each other and the superimposed belt members are used, the rigidity of the flat belt 1 with respect to the force exerted to the hole portions of the through holes (3,
3a, 3b) may be increased. Also, in the case that the load torque is produced to the tension member 2 around which the
20 flat belt 1 is wound, the plural belt members are deformed having the substantially same shape in response to a change in the belt tension. As a result, the operation force is not given to the through-hole portion of a single flat belt 1 in a concentration manner, and also, the destruction of this
25 through-hole portion can be effectively prevented, resulting

in stable belt driving operations.

Moreover, in this embodiment, since the flat belt 1 is equipped with the respective through holes 3, 3a, 3b, the belt members which are superimposed with each other are preferably 5 and mutually positioned with each other.

In this case, at least one portions of the belt members are required to be fixed. As a fixing method for the belt members, one portions of these belt members are welded, or adhered to each other. As a result, these belt members can 10 be always and firmly superimposed with each other, while each of these belt members need not be initially positioned (namely, initial positioning along belt travel direction and along direction perpendicular to this belt travel direction).

[0048]

15 [Embodiment of the Invention]

Referring now to the accompanying drawings, the present invention will be described in detail.

O Embodiment 1

Fig. 4 is a sectional diagram for schematically representing 20 an embodiment 1 of a copying machine (image forming apparatus) 80 to which the present invention is applied.

In this drawing, an arrangement of this copying machine 80 will now be explained, while this arrangement is subdivided into an image input system, an image forming system, and a 25 sheet transporting system.

The image input system is provided with an original mounting base 70 on which an original is mounted, an original reading apparatus 71 for reading the original mounted on this original mounting base 70, and an image processing apparatus 72 for 5 processing image information read by this original reading apparatus 71.

The image forming system is provided with an image forming station 10, an exposing apparatus 13, two first intermediate transfer drums 31, and one second intermediate transfer drum 10 32. The image forming stations 10 (concretely speaking, reference numerals 10K, 10Y, 10M, 10C, namely, portions surrounded by dotted lines in this drawing) correspond to each of black, yellow, magenta, and cyan colors. The exposing apparatus 13 (concretely speaking, reference numerals 13K to 15 13C) expose the image forming stations 10 in response to image data supplied from the image processing apparatus 72. Images formed in the respective image forming stations 10 are sequentially transferred to and held on the two first intermediate transfer drums 31 (concretely speaking, reference 20 numerals 31a and 31b).

[0049]

In this case, each of the image forming stations 10 is equipped with electrophotographic devices such as a photosensitive drum 11 (concretely speaking, reference numerals 25 11K to 11C), a charging apparatus 12 (concretely speaking,

reference numerals 12K to 12C) charging the photosensitive drum 11, a developing apparatus 14 (concretely speaking, reference numerals 14K to 14C) developing a latent image written on the charged photosensitive drum 11 by using the exposing apparatus 13 by using the respective color toners and the like.

Incidentally, (primary) transferring apparatus (not shown) are arranged at portions where the respective photosensitive drums 11 (11K to 11C) and the first immediate transfer drums 31a and 31b face to each other and (secondary) transferring apparatus (not shown) are provided at portions where the first intermediate transfer drums 31a and 31b and the second intermediate transfer drum 32 face to each other.

[0050]

Furthermore, the sheet transporting system is provided with a sheet tray 40 on which recording sheets such as paper are stacked/mounted, a pick-up roller 41 for picking up the recording sheets in the sheet tray 41 one by one, a register roller 42 for positioning the picked-up recording sheets, a (thirdly) transfer roller 43 for transferring the image on the second intermediate transfer drum onto the recording sheets, a fixing roller 44 for fixing the image transferred onto the recording sheets, and an ejection tray 45 for storing thereinto the ejected recording sheet.

[0051]

Next, a description will now be made of basic full-color

copying operations of such a copying machine 80.

First, when a user mounts an original to be read on the original mounting base 70, and then, instructs a full-color copying operation by using a user interface (not shown), the 5 image reading apparatus 71 scans this original so as to optically read the content of this scanned original, and then, converts the read original content into an electric signal (image data "I"). This image data I is color-separated into a black color, a yellow color, a magenta color, and a cyan color in the image 10 processing apparatus 72. Also, this image processing apparatus 72 performs such an image processing operation that a predetermined weighting factor in which a characteristic of marking device/process is taken into consideration is applied to the image data "I (namely, IK, IY, IM, IC)" having these 15 colors.

[0052]

On the other hand, the photosensitive drums 11 employed within the respective image forming stations 10 are rotary-driven by a belt driving apparatus 100 (see Fig. 5 and Fig. 6, will 20 be explained later) along directions indicated by arrows as shown in this drawing. The surfaces of these photosensitive drums 11 are uniformly charged at a predetermined potential by the charging apparatus 12. Then, the respective exposing apparatus (13K to 13C) expose exposure light corresponding 25 to the respective image data I(IK to IC) onto the surfaces

of the respective photosensitive drums 11 (11K to 11C) at predetermined timing, so that latent images are formed by potential differences on the surfaces of the respective photosensitive drums 11 (11K to 11C). The latent images are 5 converted into toner images "T" (K, Y, M, C) in such a manner that the toners are electrostatically adhered onto these latent images by the respective developing apparatus 14 (14K to 14C).

[0053]

On the other hand, both the first intermediate transfer 10 drums 31a/31b, and the second intermediate transfer drum 32 are rotary-driven by the belt driving apparatus 100 (see Fig. 5 and Fig. 6, will be explained later) along directions indicated by arrow, as shown in this drawing. Then, this toner image T(K, Y) is electrostatically transferred from the photosensitive 15 drum 11 (11K, 11Y) to the first intermediate transfer drum 31a by a primary transferring apparatus (not shown) and the toner image T(M, C) is electrostatically transferred (primary transfer) from the photosensitive drum 11 (11M, 11C) to the first intermediate transfer drum 31b. In this case, the toner 20 image T(K, Y) is superimposed with each other on the surface of the first intermediate transfer drum 31a and the toner image T(M, C) is superimposed with each other on the surface of the first intermediate transfer drum 31b.

[0054]

25 Furthermore, the toner image T(KY) superimposed with each

other on the first intermediate transfer drum 31a is electrostatically transferred (secondary transfer) to the second intermediate transfer drum 32 by a secondary transferring apparatus (not shown), and similarly, the toner image (MC) 5 superimposed with each other on the first intermediate transfer drum 31b is electrostatically transferred to this secondary intermediate transfer drum 32. In this case, the toner image T(KY) is superimposed with the toner image T(MC) on the surface of the second intermediate transfer drum 32, so that a 10 full-colored toner image (KYMCA) is formed thereon.

As explained above, while the toner image T(KYMCA) is formed, one sheet of the recording sheet "S" stored in the sheet tray 40 is picked-up by the pick-up roller 41, and then, is transported to the register roller 42. For instance, the register roller 15 42 starts to be rotated from the stop condition up to predetermined timing, whereby a timing when the full-colored toner image T(KYMCA) electrostatically formed on the second intermediate transfer drum 32 is reached to a nip portion (not shown) with respect to the transfer roller 43 coincident with another timing 20 when the recording sheet S is reached to this nip portion. Thus, the full-colored toner image T(KYMCA) formed on the second intermediate transfer drum 32 is electrostatically transferred to the recording sheet S.

Thereafter, when the recording sheet S passes through 25 the nip portion of the fixing roller 44, while the full-colored

toner image T(KYMC) is electrostatically held on the surface of this recording sheet S, this full-colored toner image T(KYMC) is fixed on this surface by receiving heat (thermal energy) and pressure given from the respective fixing rollers 44 and 5 also effects thereof, and then, the recording sheet S on which the full-colored toner image has been fixed is ejected to the ejection tray 45 provided outside the copying machine 80.

While such a series of copying steps is defined as one cycle, this copy cycle is continuously carried out, so that 10 full-colored images can be successively copied.

[0055]

Fig. 5 is a perspective view showing the belt driving apparatus 100 which drives this copying machine 80. This drawing shows a structure of this belt driving apparatus 100, as viewed 15 from a rear surface side of Fig. 4. Incidentally, Fig. 6(a) is an explanatory diagram showing a front view of the belt driving apparatus 100 of Fig. 5, and Fig. 6(b) is an explanatory diagram showing a plan view thereof.

In the drawings, the belt driving apparatus 100 is employed 20 so as to drive the respective photosensitive drums 11 (11K to 11C), the first intermediate transfer drums 31a, 31b, and also the second intermediate transfer drum 32. This belt driving apparatus 100 is provided with two flat belts 101/102, and various sorts of tension members on which these flat belts 25 101 and 102 are tensioned, or worn.

In this case, as the above-described tension member, there are driven pulleys 111 to 117, and tension pulleys 121 and 122 for circulating the respective flat belts 101/102. The driven pulleys 111 to 117 are mounted on one ends of the respective 5 photosensitive drums 11 (11K to 11C), the first intermediate transfer drums 31a/31b, and the second intermediate transfer drum 32 along axial directions thereof.

Incidentally, in this embodiment, the driven pulley 117 mounted on the second intermediate transfer drum 32 owns a 10 two-stage belt hanging plane over which the first flat belt 101 and the second flat belt 102 are hung, respectively.

[0056]

Then, the first flat belt 101 is hung over the tension pulley 121, the driven pulleys 111 to 114 which are mounted 15 on the axes of the respective photosensitive drums 11 (11K to 11C), and the driven pulley 117 which is mounted on the axis of the second intermediate transfer drum 32.

On the other hand, the second flat belt 102 is hung over the tension pulley 122, the driven pulleys 115 and 116 which 20 are mounted on the axes of the first intermediate drums 31a/31b, and the driven pulley 117 which is mounted on the axis of the second intermediate transfer drum 32.

Incidentally, pulley shafts (not shown) provided with the respective pulleys 111 to 117, 121, and 122 are supported 25 by respective slide bearings which are provided on side surfaces

of the copying machine 80, and therefore, these pulley shafts can be freely rotated.

[0057]

In this case, the way how to apply power derived from
5 a driving motor (drive source, i.e., not shown) to which shaft is that it is preferable to employ such configuration that the driving force derived from the driving motor is inputted to a pulley shaft having large winding angles between flat belts and pulleys.

10 In this embodiment, for instance, the driving force derived from the driving motor may be set to be inputted to the shaft of the second intermediate transfer drum 32. Alternatively, the driving force derived from the driving motor may be inputted to another pulley shaft.

15 Resin materials may be employed as manufacturing materials of these flat belts 101 and 102. However, metal materials such as stainless steel, nickel, and titanium are preferably used in view of durability and processing precision etc. More specifically, stainless steel is more preferably employed in
20 view of cost, durability, and mechanical strengths etc.

Similarly, resin materials may be employed as manufacturing materials of these pulleys, however, metal materials such as stainless steel, aluminum, and carbon steel are preferably used in view of durability and processing precision etc. More
25 specifically, generally speaking, a pulley made of a metal

owns larger inertia moment, as compared with a pulley made of resin. As a result, this metal pulley may expect an attenuation effect with respect to high frequency vibrations such as mesh vibrations, which may induce a problem, i.e.,

5 image defect of an image outputted from an image forming apparatus.

In view of this attenuation effect, a metal material is preferably employed as this pulley material. In particular, a stainless steel is more preferably employed as this pulley material among the metal materials in view of these cost,

10 durability, and mechanical strengths.

[0058]

Fig. 7 is an explanatory diagram showing structures of a flat belt and a pulley more in detail.

In this case, the flat belts 101/102 and the respective
15 pulleys 110 (namely 111 to 117, 121, 122), which are employed so as to drive the intermediate transfer drums of Fig. 4, will now be described as an example.

A not shown cleaner abuts against the first intermediate transfer drums 31a and 31b shown in Fig. 4, and thus, a relatively
20 heavier load is given to these first intermediate transfer drums, as compared with other drums. As a consequence, in this embodiment, plural columns (three columns in this example) of through holes 130 are formed in the first and second flat belts 101 and 102 along travel directions thereof. Also, plural
25 columns (three columns in this example) of projections 140

are formed on either all or a portion of these pulleys 110 (a case of all pulleys is illustrated in this example). These projections 140 are located in correspondence with the through holes 130 of the flat belts 101 and 102. Since the projections 5 140 of the pulley 110 are fitted to the through holes 130 of the flat belts 101/102, the stable driving operations of the flat belts 101/102 is realized.

In this embodiment, for example, circular holes are employed as the through holes 130 and semi-spherical-shaped projections 10 are used as the projections 140.

[0059]

In this embodiment shown in Fig. 7(a), 7(b), 7(c), the pitches of these through holes 130 along all of the columns are set to the same intervals (equi-interval) in the flat bets 15 101 and 102. However, the present invention is not limited thereto, but the intervals may be changed in the respective columns. Also, among the three columns of through holes, a pitch "p" of a central column of the through holes 130b is made equal to pitches "p" of both side columns of the through 20 holes 130a and 130c. However, a phase " θ " is shifted by 180 degrees.

This phase-shift setting is intended so as to avoid destruction of through-hole portions which are caused by belt meanders (will be explained later).

25 Also, in this embodiment, while the plural columns of

through holes 130 are formed in the flat belts 101 and 102, the plural columns of projections 140 are formed in correspondence with the above-explained through holes 130 in the pulley 110. However, these projections 140 need not be 5 provided in correspondence with all of these through holes 130, but may be provided on at least a pulley 110 having the largest load.

As a result, the projections 140 need not be fitted to all of the columns of these through holes 130, but may be fitted 10 only to one column among the three columns thereof.

Alternatively, the pitch of these projections 140 may be made equal to a pitch larger than the through-hole pitch multiplied by an integer. As a result, the fitting specifications of the flat belts 101/102 in which the plural columns of through 15 holes 130 are formed, and also, the fitting specifications of the several pulleys 110 around which the flat belts 101 and 102 are wound may be freely designed every use case.

[0060]

Fig. 8(a) and Fig. 8(b) shows a summary of effects with 20 respect to the load of the structure of the image forming apparatus according to this embodiment, and Fig. 8(c) and Fig. 8(d) shows a summary of effects with regard to the belt meandering operations thereof more in detail.

Fig. 8 shows both a perforation belt moved in a circulation 25 manner along a direction indicated by an arrow (namely, flat

belt equipped with through holes) and projections which are provided on a pulley and are fitted to through holes formed in this flat belt.

Fig. 8(a) shows a drive condition in a comparison mode 5 (flat belts 101' and 102') in which one column of through holes 130' are formed. In a case of a heavy load, as indicated in this drawing, the flat belts 101' and 102' are moved along a direction opposite to the circulation direction of the through holes 130', so that a distortion is produced at portions where 10 these through holes 130' are engaged with the projections 140'. When a magnitude of this distortion becomes larger than, or equal to a certain magnitude, a belt portion of the through hole 130' is destroyed, so that the belt drive operation is brought into unstable drive operation.

15 In order to reduce adverse influences of this distortion to drive the belts under stable conditions, in this embodiment, as shown in Fig. 8(b), plural columns of through holes 130 are formed in the flat belts 101 and 102 with respect to circulation directions. As a result, a distortion occurred in a portion 20 of one through hole 130 when the pulley 110 to which a heavy load is given is driven can be reduced, and thus, driving force can be transferred under stable condition.

[0061]

Fig. 8(c) shows a modification mode in which the plural 25 columns of through holes 130 are formed in the flat belts 101

and 102 to have the same phase condition in this embodiment.

In this case, similar effects to those of Fig. 8(b) may be achieved with respect to a load, and thus, a distortion occurred per a single hole portion of the through hole 130 5 may be reduced. However, under such a condition that belt meandering operations are produced, the pitches of the hole portions of the through holes 130 with respect to the meander direction are excessively narrowed, so that there is no region capable of absorbing distortions, which may readily conduct 10 destruction of hole portions of these through holes 130.

To avoid this problem, when the belt meander direction is considered, as explained in this embodiment, it is preferable to employ a belt structure as indicated in Fig. 8(d).

To this end, in the case that widths of flat belts are 15 made sufficiently wide, since pitches of plural columns of through holes along the meander direction is large, there is no problem even if the belt structure of Fig. 8(c) is employed.

However, in the case that a compactness of an apparatus such as an image forming apparatus is required, it is preferable 20 to employ such a belt structure shown in Fig. 8(d). As a consequence, since the belt structures as indicated in Fig. 8(b) and Fig. 8(d) are employed in this embodiment, the stable belt driving operations can be realized.

[0062]

25 Therefore, in accordance with this embodiment, there is

no risk that the hole portions of the through holes 130 formed in the flat belts 101 and 102 are destroyed, and furthermore, the driving force derived from the drive motor can be firmly transferred to the photosensitive drums 11 (11K to 11C), the 5 first intermediate transfer drums 31a/31b, and the second intermediate transfer drum 32.

This fact is proved in an example 1 (will be discussed later).

[0063]

10 More specifically, in the technical field of color image forming apparatus which have been currently and advantageously developed, in order to reduce electric power consumption and manufacturing cost, a drive system is required in which not only photosensitive drums, but also intermediate transfer drums 15 and intermediate transfer belts, and furthermore, transfer rollers and charge rollers are driven by a single drive motor. There is such a trend that load torque is gradually increased, and driving force transfer members should endure this increased load torque to realize color image forming operations.

20 In addition, in order to reduce cost of parts, there are many possibilities that as to bearings for supporting rotation shafts of respective image carrier drums, roller bearings which have been conventionally used are replaced by slide bearings. Under such a bearing change environment, load torque would 25 be increased by replacing these roller bearings with these

slide bearings.

This embodiment can achieve very large effects even under such a requirement. This merit may be similarly achieved in the below-mentioned embodiments.

5 [0064]

Incidentally, in this first embodiment, as the belt driving apparatus 100, such a belt driving apparatus has been employed which is constituted by the two flat belts 101 and 102, and the pulleys 110 (111 to 117, 121, 122) for hanging these flat belts. However, the present invention is not limited to this belt driving apparatus, but may be applied to another belt driving apparatus as shown in Fig. 9. That is, while this belt driving apparatus 100 is equipped with a single flat belt 103, and pulleys (namely, driven pulleys 111 to 117, and tension pulley 121) for hanging this single flat belt 103, for example, the driving force derived from the drive motor may be applied to the driven pulley coupled to the second intermediate transfer drum 32, and also this driving force may be transferred to the respective pulleys 110 via the single flat belt 103 which is hung over the respective pulleys 110 so as to drive the photosensitive drums 11 (11K to 11C), the first intermediate transfer drums 31a/31b, and the second intermediate transfer drum 32.

[0065]

25 O Embodiment 2

Fig. 10 is a sectional diagram for schematically representing an embodiment 2 of a copying machine (image forming apparatus) 90 to which the present invention is applied.

In this drawing, an arrangement of this copying machine 5 90 will now be explained, while this arrangement is subdivided into an image input system, an image forming system, and a sheet transporting system.

The image input system is provided with an original mounting base 70, an original reading apparatus 71, and an image processing 10 apparatus 72.

The image forming system is provided with an image forming station 10, an exposing apparatus 13, two first intermediate transfer drums 31, and one second intermediate transfer drum 32. The image forming stations 10 (concretely speaking, reference numerals 10K, 10Y, 10M, 10C, namely, portions surrounded by dotted lines in this drawing) correspond to each of black, yellow, magenta, and cyan colors. The exposing apparatus 13 (concretely speaking, reference numerals 13K to 13C) expose the image forming stations 10 in response to image 15 data supplied from the image processing apparatus 72.

In this case, the image forming stations 10 (10K to 10C) is equipped with electrophotographic devices such as a photosensitive drum 11 (concretely speaking, reference numerals 11K to 11C), a charging apparatus 12 (concretely speaking, 20 reference numerals 12K to 12C), a developing apparatus 14

(concretely speaking, reference numerals 14K to 14C), a drum cleaner 15 (concretely speaking, reference numeral 15K to 15C), and a transfer roller 22 (concretely speaking, reference numerals 22K to 22C). The charging apparatus 12 charges the 5 photosensitive drum 11. The developing apparatus 14 develops a latent image written on the charged photosensitive drum 11 by using the exposing apparatus 13, by using the respective color toners. The drum cleaner 15 cleans toners left on the photosensitive drum 11. The transfer roller 22 transfers an 10 image formed on the photosensitive drum 11 to the recording sheet "S."

In particular, in this embodiment, the photosensitive drums 11 (reference numbers 11K to 11C) are driven by belt driving apparatus 50 (concretely speaking, reference numerals 15 50K to 50C), respectively. In the belt driving apparatus 50 (reference numerals 50K to 50C), driving force derived from a single drive motor is supplied via an entire belt driving apparatus (not shown) to the driving force transfer shafts of each of belt driving apparatus 50.

20 [0066]

Further, the sheet transporting system is provided with a sheet transporting belt 20, and a fixing roller 44, and so on. This sheet transporting belt 20 transports a recording sheet "S" in correspondence with each of the image forming 25 stations 10 (reference numerals 10K to 10C) and is positioned

at a post stage of a register roller 42. The fixing roller 44 is provided at a post stage of this sheet transporting belt 20.

Then, in this embodiment, the sheet transporting belt 5 20 is tensioned and worn over a plurality of tension rollers 24 (reference numerals 24a to 24e) including at least a driving roller 24a. Around this sheet transporting belt 20, there are provided a belt cleaner 26, a belt erasing apparatus 27, a sucking electrostatic charging apparatus 28, and a stripping 10 electrostatic charging apparatus 29. The sucking electrostatic charging apparatus 28 sucks and holds the recording sheet "S" onto the sheet transporting belt 20. The stripping electrostatic charging apparatus 29 stripes the recording sheet "S" from the sheet transporting belt 20.

15 [0067]

Next, a description will now be made of basic full-color copying operations of such a copying machine 80.

First, when a user mounts an original to be read on the original mounting base 70, and then, instructs a full-color 20 copying operation by using a user interface (not shown), the image reading apparatus 71 scans this original so as to optically read the content of this scanned original, and then, converts the read original content into an electric signal (image data "I"). This image data I is color-separated into a black color, 25 a yellow color, a magenta color, and a cyan color in the image

processing apparatus 72. Also, this image processing apparatus 72 performs such an image processing operation that a predetermined weighting factor in which a characteristic of a marking device/process is taken into consideration is applied 5 to the image data "I (namely, IK, IY, IM, IC)" having these colors.

[0068]

On the other hand, the photosensitive drums 11 employed within the respective image forming stations 10 are rotary-driven 10 by a belt driving apparatus 50 (reference numerals 50K to 50C) along directions indicated by arrows as shown in this drawing.

The surfaces of these photosensitive drums 11 (reference numerals 11K to 11C) are uniformly charged at a predetermined potential by the charging apparatus 12 (reference numerals 15 12K to 12C). Then, the respective exposing apparatus 13 (13K to 13C) expose exposure light corresponding to the respective image data I(IK to IC) onto the surfaces of the respective photosensitive drums 11 (11K to 11C) at predetermined timing, so that latent images are formed by potential differences on 20 the surfaces of the respective photosensitive drums 11 (11K to 11C). The latent images are converted into toner images "T" (K, Y, M, C) in such a manner that the toners are electrostatically adhered onto these latent images by way of the respective developing apparatus 14 (14K to 14C).

25 [0069]

As explained above, while the toner image T (K, Y, M, C) is formed, one sheet of the recording sheet "S" stored in a sheet tray (not shown) is picked-up by a pick-up roller 41 (not shown), and then, is transported to the register roller 42. For instance, since the register roller 42 starts to be rotated from the stop condition up to predetermined timing, the recording sheet "S" is transferred to the sheet transporting belt 20 which is rotary-driven by a driving apparatus (not shown) along a direction denoted by an arrow of this drawing.

Incidentally, while the recording sheet "S" is transferred from the register roller 42 to the sheet transporting belt 20, electron charges are applied from the sucking electrostatic charging apparatus 28 to the sheet transporting belt 20 in such a manner that this recording sheet "S" is sucked to the sheet transporting belt 20.

[0070]

Then, the toner images T (K, Y, M, C) formed on the photosensitive drums 11 (11K to 11C) are sequentially transferred from the respective photosensitive drums 11 (11K to 11C) onto the sheet transporting belt 20 by the transfer roller 22 (22K to 22C) in an electrostatic manner. In this case, the toner image T(K) is firstly transferred (primary-transferred) onto the recording sheet "S", the toner image T(Y) is transferred onto this toner image T(K), and then, the toner image T(M) is transferred onto this toner image T(Y), and furthermore,

the toner image T(C) is superimposed onto this toner image T(M) in a sequential manner. As a result, a full-colored toner image T (K, Y, M, C) is formed.

Incidentally, articles such as toners which are partially left on the surfaces of the respective photosensitive drums 11 (11K to 11C) after the primary transfer operation is eliminated by drum cleaners 15 (reference numerals 15K to 15C). Also, articles such as toners which remain on the surface of the sheet transporting belt 20 is removed by the belt cleaner 26. Furthermore, potential histories which are left on the sheet transporting belt 20 is eliminated by the belt erasing apparatus 27.

[0071]

Thereafter, when the recording sheet S passes through the nip portion of the fixing roller 44, while the full-colored toner image T (K, Y, M, C) is electrostatically held on the surface of this recording sheet S, this full-colored toner image T (K, Y, M, C) is fixed on this surface by receiving heat (thermal energy) and pressure given from the respective fixing rollers 44 and also effects thereof, and then, the recording sheet "S" on which the full-colored toner image has been fixed is ejected to the ejection tray 45 provided outside the copying machine 90.

In this case, when the recording paper "S" is transferred from the sheet transporting belt 20 to the fixing roller 44,

such electron charges are applied by the stripping electrostatic charging apparatus 29 to the recording sheet "S", by which this recording sheet "S" is stripped from the sheet transporting belt 20.

5 While such a series of copying steps is defined as one cycle, this copy cycle is continuously carried out, so that full-colored images can be successively copied.

[0072]

Similar to the embodiment 1, when both the flat belt equipped 10 with plural columns of holes and the pulley equipped with projections are applied to the respective belt driving apparatus 50 (50K to 50C) and the entire belt driving apparatus, which are employed so as to drive the respective photosensitive drums 11 (11K to 11C) of the copying machine 90, both operations 15 and effects similar to those of the embodiment 1 can be achieved.

Also, a belt driving apparatus similar to that of the embodiment 1 may be also applied to the driving apparatus of the sheet transporting belt 20. Alternatively, the belt driving apparatus similar to those of the embodiment 1 may be applied 20 to both apparatus.

[0073]

O Embodiment 3

Any of the above-described embodiments 1 and 2 represent the belt driving apparatus applicable to the image forming 25 apparatus. In contrast, this embodiment shows a typical mode

of belt driving apparatus for widely driving a member to be driven.

A belt driving apparatus 100 related to Fig. 11(a) to Fig. 11(d) is equipped with a single flat belt 105 and tension members on which this flat belt 105 is worn. As this tension member, a drive pulley 151, two driven pulleys 152, 153, and also a tension pulley 154 are provided, to which driving force derived from a drive motor (not shown) is transferred. These driven pulleys 152 and 153 are positioned adjacent to this drive pulley 151, and are coupled to the member to be driven (not shown). The tension pulley 154 is employed so as to circulate the flat belt 105.

[0074]

Similar to the above-described embodiment 1, in this embodiment 3, plural columns (three columns in this example) of through holes 130 are formed in the flat belt 105 along a travel direction thereof. Also, plural columns of projections 140 are formed on either all or a portion of these pulleys 151 to 154 (in this example, the projections 140 are formed on the drive pulley 151, the driven pulleys 152 and 153). These projections 140 are located in correspondence with the through holes 130 of the flat belt 105. Since the projection 140 of the pulley 110 are engaged to the through holes 130 of the flat belt 105, the stable driving operation of the flat belt 105 is realized.

In accordance with this embodiment 3, similar to the embodiment 1, even in such a case that heavy loads are given to the driven pulleys 152 and 153 to which the member to be driven is coupled, and also the flat belt 105 tries to meander, 5 the driving force can be firmly transferred to the member to be driven, while the operation force given to the hole portions of the through hole 130 of the flat belt 105 is distributed.

[0075]

Also, the belt driving apparatus 100 related to Fig. 11(b) 10 is constructed of 3-column through hole type in such a manner that plural columns of through holes 131 are arrayed in an oblique manner along a belt meander direction (namely, width direction located perpendicular to travel direction), while these plural through holes 131 are not overlapped with each 15 other. Furthermore, projections 141 corresponding to the above-explained through holes 131 are provided on either all, or a portion of pulleys 151 to 154. As a result, this belt driving apparatus 100 can strength rigidity with respect to the belt width direction, as compared with the rigidity of 20 the belt driving apparatus shown in Fig. 11(a).

Further, the belt driving apparatus 100 related to Fig. 11(c) is constructed of 2-column through hole type in such a manner that plural columns of through holes 132 are arrayed in an oblique manner along a belt meander direction (namely, 25 width direction located perpendicular to travel direction),

while these plural through holes 132 are not overlapped with each other. Furthermore, projections 142 corresponding to the above-explained through holes 132 are provided on either all, or a portion of pulleys 151 to 154.

5 [0076]

Moreover, the belt driving apparatus 100 related to Fig. 11(d) is constructed of 2-column through hole type in such a manner that plural columns of through holes 133 are arrayed in a parallel manner along a belt meander direction (namely, 10 width direction located perpendicular to travel direction).

Furthermore, projections 143 corresponding to the above-explained through holes 133 are provided on either all, or a portion of pulleys 151 to 154.

This mode of the belt driving apparatus 100 shown in Fig. 15 11(d) is not suitably operated in such a case that a large belt meandering operation occurs. However, when a load is given to both the driven pulleys 152 and 153, the two columns 20 of through holes 133 are engaged with the projections at the same time to drive the belt 105. As a consequence, when a heavy load is driven by the belt 105, the array of these through holes and projections of this belt driving apparatus 100 may achieve advantages.

Therefore, several modes of these belt driving apparatus according to this embodiment are combined with each other in 25 accordance with a drive specification to be applied, and whereby

the belt can be driven under stable condition, and further, higher rotation fluctuation preventing precision can be achieved.

[0077]

5 O Embodiment 4

Fig. 12 illustratively shows an embodiment 4 of a belt driving apparatus 100 to which the present invention is applied.

This belt driving apparatus 100 shown in Fig. 12 is arranged in a substantially similar manner to that of the embodiment 10 3, namely, is provided with a single flat belt 105, and a tensions member (i.e., drive pulley 151, driven pulleys 152 and 153, and tension pulley 154) over which this flat belt 105 is tensioned.

Different from the above-described embodiment 3, in this belt drive apparatus 100, through holes having elongated-hole shapes 15 301 are formed in the single flat belt 105, as shown in this drawing. These elongated-hole shaped through holes 301 are elongated along a width direction perpendicular to a travel direction of the flat belt 105. In either all or a portion of these pulleys 151 to 154 (in this example, all pulleys), 20 pillar-shaped projections 302 having semi-circular cylinder shapes are provided in correspondence with the above-described elongated-hole shaped through holes 301. The pulley-shaped projections 302 formed on the respective pulleys 151 to 154 are engaged with the elongated-hole shaped through holes 301 25 formed in the flat belt 105, and whereby it is realized to

drive the flat belt 105 under stable condition.

[0078]

Next, the pulleys 151 to 154 and the flat 105 employed in this embodiment will be given in detail.

5 In this embodiment 4, as shown in Fig. 13(a), the pulleys 151 to 153 are provided with the pillar-shaped projections 302 having the semi-circular cylinder shapes around peripheral surfaces of these pulleys. For instance, as shown in 13(c), in these pulleys 151 to 153, pin engagement grooves 312 having 10 semi-circular cylinder shapes are formed in a properly-selected interval within a circumferential surface of a pulley main body 311, circular cylinder-shaped pins 313 are pressed and inserted into the respective pin engagement grooves 312 from an outer side of the pulley main body 311 along a radial direction 15 thereof, so that the pillar-shaped projections 302 are formed, and this pulley main body 311 is sandwiched by two holding disks 314 and 315, and the pulley main body 311 is fixed by using a fastening member 316 such as a screw.

Also, as represented in Fig. 13(b), the flat belt 105 20 is equipped with the elongated-hole shaped through hole 301. This elongated-hole shaped through hole 301 can be realized in such a way that the flat belt 105 made of, for example, an SUS material is etched away to become an elongated-hole shape. Alternatively, this elongated-hole shaped through hole 25 301 may be realized by employing a press working, and/or a

discharging working.

With respect to a relationship between the elongated-hole shaped through hole 301 and the pillar-shaped projection 302, in view of such a point that a fitting characteristic between both the members 301 and 302 is maintained under good condition, the dimension of the elongated-hole shaped through hole 301 is preferably made slightly larger than the dimension of the pillar-shaped projection 302. Then, in order to maintain the fitting characteristic between both the members 301/302 under better condition, both edge portions of the elongated-hole shaped through hole 301 along the longitudinal direction thereof are preferably made in arc shapes, and on the other hand, both end portions of the pillar-shaped projections 302 along the longitudinal direction also are preferably formed in smooth curved-plane shapes.

[0079]

As a consequence, in accordance with this embodiment, as indicated in Fig. 14, even when a heavy load is given to the driven pulleys 152 and 153 to which the member to be driven is coupled, the driving force can be firmly transferred to the member to be driven, while the operation force applied to the hole portions of the elongated-hole shaped through holes 301 of the flat belt 105 is received by a straight line portion 301a of this through hole 301.

Therefore, the structure of the belt driving apparatus

according to this embodiment is employed, and whereby the stable belt driving operation can be carried out, and further, the higher rotation fluctuation preventing precision can be achieved.

5 [0080]

O Embodiment 5

Fig. 5 shows a main portion of a belt driving apparatus of an embodiment 5 to which the present invention is applied.

As indicated in Fig. 15, in this embodiment 5, both
10 elongated-hole shaped through holes 321 extended along a direction perpendicular to a travel direction of this flat belt 105 and circular-shaped through holes 322 are alternatively formed in a predetermined pitch interval in a flat belt 105.
Also, both pillar-shaped projections 323 having semi-circular
15 cylinder shapes and semi-spherical shaped projections 324 are formed on either all or a portion of pulleys 151 to 154 in correspondence with the above-described through holes 321 and 322. The respective projections 323 and 324 of the pulleys 151 to 154 are fitted to the respective through holes 321 and
20 322 formed in the flat belt 105, and whereby the stable driving operation of the flat belt 105 can be realized.

[0081]

For instance, in the embodiment 4, when the pulleys 151 to 154 are manufactured by way of the method indicated in Fig.
25 13(c), since the pillar-shaped projection 302 is sandwiched

by the two holding disks 315 and 316, it is preferable to employ the circular cylinder pin 313, which constitutes the pillar-shaped projection 302, having a shorter width than the width of the central pulley main body 311 sandwiched by these 5 holding disks.

However, if the manufactured pillar-shaped projection 302 having the semi-circular cylinder shape owns a fluctuation with respect to the positions along the axial directions of the pulleys 151 to 154, in such a case that the flat belt 105 10 is driven in the meander manner, then only one piece of these elongated-hole shaped through holes 301 restricts the meandering drive of this flat belt 105 in the worst case. As a result, there is a risk that large operation force is applied to this elongated-hole shaped through hole 301.

15 As indicated in Fig. 15, in accordance with this embodiment, the arrangement of the belt driving members is set in such a manner that a relationship of " $d_1 \leq d_3 \leq d_2$ " can be satisfied based upon the following assumptions. That is, a space between 20 an edge portion of the pillar-shaped projection 323 and an edge portion of the elongated-hole shaped through hole 321 along the travel direction of the flat belt 105 is assumed as " d_1 "; another space between an edge portion of the pillar-shaped projection 323 and an edge portion of the elongated-hole shaped through hole 321 along the width direction 25 of the flat belt 105 is assumed as " d_2 "; and also, another

space between an edge portion of the semi-spherical shaped projection 324 and an edge portion of the circular-shaped through hole 322 along the width direction of the flat belt 105 is assumed as "d3".

5 [0082]

When the structural members of the belt driving apparatus are set to satisfy such a dimensional relationship, a function separate type belt driving apparatus can be realized. That is, the meandering operation of the flat belt 105 is restricted 10 by the semi-spherical shaped projections 324 and the circular-shaped through holes 322 of this flat belt 105. Also, in relation to the operation force caused by the load torque, the flat belt 105 is driven/transported under such a condition that this operation force is distributed by the pillar-shaped 15 projections 323 having the semi-circular cylinder shapes and the elongated-hole shaped through hole 324 of the flat belt 105.

As a consequence, similar to the embodiment 4, even when the heavy load is given to the driven pulleys 152 and 153 to 20 which the member to be driven is coupled, and also, the flat belt 105 is driven in the meandering manner, the driving force can be firmly transferred to the member to be driven, while the operation force given to the through holes (elongated-hole shaped through holes 321 and circular-shaped through holes 25 322) formed in the flat belt 105 is distributed. This operation

force is produced by both the force exerted along the travel direction of the flat belt, which is caused by the load, and the force caused by the meandering drive of the flat belt 105 along the direction substantially perpendicular to the travel 5 direction.

[0083]

O Embodiment 6

Fig. 16 shows an embodiment 6 of a belt driving apparatus to which the present invention is applied.

In this drawing, the belt driving apparatus according to this embodiment is arranged in a substantially similar manner to that of the above-described embodiment 5. Different from the embodiment 5, in this belt driving apparatus, elongated-hole shaped through holes 321 extended along a direction perpendicular to the travel direction of this flat belt 105 are formed in the flat belt 105 in a predetermined pitch interval, as shown in this drawing, and both pillar-shaped projections 323 having semi-circular cylinder shapes and semi-spherical shaped projections 325 having pair structures are alternately provided in a predetermined pitch interval (the predetermined pitch interval is set to be twice longer than the pitch interval of the elongated-hole shaped through holes 321 in this example) in either all or a portion of pulleys 151 to 154 in correspondence with the above-explained elongated-hole shaped through holes 321, and the respective projections 323 and 325 of the pulleys

151 to 154 are fitted to the respective through holes 321 formed in the flat belt 105, whereby the stable driving operation of the flat belt 105 can be realized.

[0084]

5 As a consequence, as indicated in Fig. 6(a), in accordance with this embodiment, the arrangement of the belt driving members is set in such a manner that a relationship of " $d_1 \leq d_3 \leq d_2$ " can be satisfied based upon the following assumptions. That is, a space between an edge portion of the pillar-shaped projection 323 and an edge portion of the elongated-hole shaped through hole 321 along the travel direction of the flat belt 105 is assumed as " d_1 "; another space between an edge portion of the pillar-shaped projection 323 and an edge portion of the elongated-hole shaped through hole 321 along the width direction of the flat belt 105 is assumed as " d_2 "; and also, another space between an edge portion of the semi-spherical shaped projection 325 and an edge portion of the circular-shaped through hole 322 along the width direction of the flat belt 105 is assumed as " d_3 ".

10 [0085]

15 When the structural members of the belt driving apparatus are set to satisfy such a dimensional relationship as shown in Fig. 16(b), a function separate type belt driving apparatus can be realized. That is, the meandering operation of the 20 flat belt 105 is restricted by the semi-spherical shaped

projections 325 and the elongated-hole through holes 321 of this flat belt 105. Also, as to the operation force caused by the load torque, the flat belt 105 is driven/transported under such a condition that this operation force is distributed 5 by the pillar-shaped projections 323 having the semi-circular cylinder shapes and the elongated-hole shaped through hole 324 of the flat belt 105.

Accordingly, in the embodiment mode, even when the heavy load is given to the driven pulleys 152 and 153 to which the 10 member to be driven is coupled and the flat belt 105 is driven in the meandering manner, the driving force can be firmly transferred to the member to be driven, while the operation force (the force exerted along the travel direction of the flat belt, which is caused by the load, and the force caused 15 by the meandering drive of the flat belt 105 along the direction substantially perpendicular to the travel direction) given to the hole portions of the elongated-hole shaped through holes 321 formed in the flat belt 105 is distributed.

[0086]

20 In particular, in this embodiment, since the elongated-hole shaped through holes 321 are formed in the predetermined pitch interval in the flat belt 105, the patterns of the various sorts of projections which are constituted on the side of the pulleys are increased the degree of freedom.

25 For example, the pillar-shaped projections 301 (321) may

be formed every arranging pitch interval of the elongated-hole shaped through holes 321. Also, both the pillar-shaped projections 323 and the pair-constructed semi-spherical shaped projections 325 may be formed in such an interval twice longer than the arranging pitch of the elongated-hole shaped through hole 321. Both the pillar-shaped projections 323 and the pair-constructed semi-spherical shaped projections 325 may be formed in a ratio of 2:1 with respect to the elongated-hole shaped through holes 321.

10 [0087]

O Embodiment 7

Fig. 17 shows a belt driving apparatus which is applied to a copying machine (image forming apparatus) 80 of an embodiment 7 to which the present invention is applied.

15 In this drawing, a basic arrangement of the copying machine 80 is substantially similar to that of the embodiment 1, and is equipped with four photosensitive drums 11 (reference numerals 11K to 11C), two first intermediate transfer drums 31a and 31b, and a second intermediate transfer drum 32. However, 20 an construction of a belt driving apparatus 160 employed in this embodiment 7 is different from that of the embodiment 1. Incidentally, the same, or similar reference numerals shown in the embodiment 1 will be employed as those for denoting the same, or similar structural elements of this embodiment 25 7, and therefore, detailed explanations thereof are omitted.

In this embodiment, as shown in Fig. 17 to Fig. 19, the belt driving apparatus 160 drives respective photosensitive drums 11 (11K to 11C), first intermediate transfer drums 31a, 31b, and a second intermediate transfer drum 32. This belt 5 driving apparatus 160 is provided with two flat belts 171, 172, and various sorts of tension members on which these flat belts 171 and 172 are tensioned or worn.

In this case, as the above-described tension member, there are driven (driven) pulleys 181 to 187, and tension pulleys 10 191 and 192 for circulating the respective flat belts 171 and 172. The driven pulleys 181 to 187 are mounted on one ends of the respective photosensitive drums 11 (11K to 11C), the first intermediate transfer drums 31a and 31b, and the second intermediate transfer drum 32 along axial directions thereof, 15 respectively.

Incidentally, in this embodiment, the driven pulley 187 mounted on the second intermediate transfer drum 32 has a two-stage belt hanging plane over which the first flat belt 171 and the second flat belt 172 are hung.

20 [0088]

Then, the first flat belt 171 is hung over the tension pulley 191, the driven pulleys 181 to 184 which are mounted on the axes of the respective photosensitive drums 11 (11K to 11C), and the driven pulley 117 which is mounted on the 25 axis of the second intermediate transfer drum 32.

On the other hand, the second flat belt 172 is hung over the tension pulley 192, the driven pulleys 185 and 186 which are mounted on the axes of the first intermediate drums 31a and 31b, and the driven pulley 187 which is mounted on the 5 axis of the second intermediate transfer drum 32.

Incidentally, pulley shafts (not shown) provided with the pulleys 181 to 187, 191, and 192, respectively, are supported by respective slide bearings which are provided on side surfaces of the copying machine 80, and therefore, these pulley shafts 10 can be freely rotated. Also, in this example, among the two-stage belt hanging planes of the driven pulley 187, the diameter of the belt hanging plane provided for the first flat belt 171 is formed larger than the diameter of the belt hanging plane provided for the second flat belt 172.

15 More specifically, in accordance to this embodiment, while the flat belts 171 and 172 are equipped with, for instance, one column of through holes 175 along travel directions of these flat belts 171 and 172, respectively, projections 176 corresponding to the above-described through holes 175 are 20 provided on either all of a portion of the pulleys over which these flat belts 171 and 172 are hung. These flat belts are constituted by such a perforation belt capable of transferring driving force by fitting these projections 176 to the through holes 175.

In this case, as to a way how to apply power derived from a driving motor (drive source not shown) to which shaft, it is preferable that the driving force derived from the driving motor is entered to a pulley shaft, whose winding angles between 5 flat belts and pulleys are large.

In this embodiment, for instance, the driving force derived from the driving motor may be entered to the shaft of the second intermediate transfer drum 32. Alternatively, the driving force derived from the driving motor may be entered into another 10 pulley shaft.

Also, with respect to materials of these flat belts and materials of these pulleys, any materials may be properly selected in a similar manner to that of the embodiment 1. For example, as these flat belts, metal materials such as 15 stainless steel, nickel, and titanium are preferably used in view of durability and processing precision etc. On the other hand, as materials of these pulleys, metal materials such as stainless steel, aluminum, and carbon steel are preferably used in view of durability and processing precision etc.

20 [0090]

In particular, in this embodiment, free rotating members 200 (concretely speaking, reference numerals 200a and 200b) are mounted on the driven pulleys 185 and 186 of the first intermediate transfer drums 31a and 31b. The free rotating 25 members 200 are freely rotatable and are positioned in a coaxial

manner to shafts of these driven pulleys 185 and 186. The flat belt 171 is worn via the free rotating member 200a over the driven pulleys 181 and 182 of the photosensitive drums 11 (11K, 11Y). On the other hand, the flat belt 171 is worn 5 via the free rotating member 200b over the driven pulleys 183 and 184 of the photosensitive drums 11 (11M, 11C).

In this case, as the free rotating members 200, various sorts of members may be freely selected, for instance, a collar is selectable if these selected members are freely rotatable 10 with respect to the shafts of the driven pulleys. In this example, for example, as illustrated in Fig. 20(a), a ball bearing is employed. This ball bearing is constituted by an inner ring case 201 and an outer ring case 202. The inner ring case 201 is inserted under pressure and coupled to the 15 shafts of the above-explained driven pulleys 185 and 186. The outer ring case 202 is rotatably provided via a ball 203 on the outer side of the inner ring case 201.

[0091]

Also, the free rotating members 200 may preferably restrict 20 the positions of the first intermediate transfer drums 31a and 31b with respect to the axial direction of the rotary shaft 310.

When the above-described free rotating members 200 has the degree of freedom along the axial direction, this may cause 25 the meandering operations of the flat belts 171 and 172 to

occur. For example, in a case that a flat belt equipped with holes such as a perforation belt is used, either the projections 176 formed on the driven pulleys 181 and 182 provided for the photosensitive drums 11 (namely, drums 11K and 11Y in this 5 example) or the projections 176 formed on the driven pulleys 183 and 184 provided for the photosensitive drums 11 (namely, drums 11M and 11C in this example) are rubbed with the through holes 175 formed in the flat belts 171 and 172, so that the hole portions of the through holes 175 is easy to destroy.

10 The driven pulleys 181 and 182 are located on the upper stream side of the free rotating members 200, whereas the driven pulleys 183 and 184 are located on the lower stream side thereof.

In this case, as the axial direction restriction of the free rotating member 200, as shown in Fig. 20(b), for example, 15 a position restricting member 210 such as an E-ring and an O-ring may be provided on both sides, or one side of this free rotating member 200. In this example, the position restricting members 210 are provided on both sides of the free rotating member 200.

20 [0092]

Also, in this embodiment, the flat belts 171 and 172 are worn over the peripheral planes of the free rotating members 200. As indicated by a virtual line of Fig. 20(b), it is preferable that while projections 205 are provided on the 25 peripheral planes of the free rotating member 200 (in this

case, peripheral plane of outer ring case 202) in correspondence with the through holes 175 of the flat belts 171 and 172, the positional restriction is carried out with respect to the axial directions between the free rotating member 200 and the flat 5 belts 171 and 172.

[0093]

Next, a description will be given on operations of the belt driving apparatus of the image forming apparatus according to this embodiment.

10 In this embodiment, when driving force derived from a drive motor is entered to the rotation shaft of the second intermediate transfer drum 32, the driven pulley 187 of this second intermediate transfer drum 32 is rotated, so that the driving force is transferred via the second flat belt 172, 15 the driven pulleys 185 and 186, and the tension pulley 192 to the first intermediate transfer drums 31a and 31b.

On the other hand, when the driven pulley 187 of the second intermediate transfer drum 32 is rotated, the driving force is transferred via the first flat belt 171, the driven pulleys 20 181 to 184, the tension pulley 192, and the free rotating members 200 (namely, members 200a and 200b) to the respective photosensitive drums 11 (namely, drums 11K to 11C).

[0094]

At this time, the first flat belt 171 is worn via the 25 free rotating member 200a, the tension pulley 191, and the

rotating member 200b over the driven pulleys 181 to 184, which are located adjacent to the respective photosensitive drums 11 at a winding angle larger than or equal to approximately 180 degrees.

5 Under this condition, since the winding regions between the first flat belt 171 and the respective driven pulleys 181 to 184 are increased, not only transferring the driving force applied to the driven pulleys 181 to 184 is stable, but also since the force exerted to the hole portions of the through holes 175 is distributed, which is caused by fitting the through holes 175 of the first flat belt 171 to the projections 176 of the driven pulleys 181 to 184, the destruction of the hole portions of the through holes 175, which is caused by that local stress is applied to the hole portions of the through holes 175, can be advantageously avoided.

10

15

[0095]

Particularly, in this example, although the rotation shaft direction of the first intermediate transfer drums 31a and 31b is reversed with respect to the rotation direction of the free rotating member 200, since the free rotating member 200 can be freely rotated with respect to the rotation shafts of the first intermediate transfer drums 31a and 31b, movement of the first flat belt 171 is not deteriorated.

20

Assuming now that the free rotating member 200 is not employed, the first flat belt 171 is directly worn on the rotation

25

shafts of the first intermediate transfer drums 31a and 31b.

However, in this assumption case, both a load and a driving load given to the flat belt 171 are increased and the damage of the first flat belt 171 caused by this friction would be

5 increased, thus to be undesirable.

[0096]

In addition, since the free rotating members 200 use the rotation shafts of the first intermediate transfer drums 31a and 31b as the supporting members, the exclusively-used tension 10 pulley supporting member is not required. Also, the installation space of the free rotating members 200 is not unnecessarily enlarged.

[0097]

The belt driving apparatus 160 according to the embodiment 15 is not limited only to the above-explained structures, but also this design of the belt driving apparatus 160 may be changed as shown in, for example, Fig. 21.

The belt driving apparatus 160 shown in Fig. 21 utilizes a mode with employment of a speed reduction mechanism.

20 In this drawing, the speed reduction mechanism is that driving force derived from a drive motor (not shown) is entered into a shaft 220 by which a drive pulley 221 is rotatably supported, a rotation speed is reduced by way of a belt transmission, and the driving force is transferred to an output axis.

25 In this case, a rotation shaft of a driven pulley 231

and a rotation shaft of a driven pulley 232 are common. A first flat belt 241 is worn over a drive pulley 221 which accepts input power supplied from the drive motor and is worn over the driven pulley 231. On the other hand, a second flat belt 5 242 is worn between the driven pulley 232 and another driven pulley 251 provided at an output shaft 250.

[0098]

In such a reduction mechanism, in a case that a heavy load is given to the output shaft 250, a belt tensile load 10 given to the first flat belt 241 is different from a belt tensile load given to the second flat belt 242. The second flat belt 242 receives larger tensile load force. As a result, there is a risk that such a winding angle which is sufficient in the first flat belt 241 in view of slips may be insufficient 15 in the second flat belt 242.

Under such a circumstance, in a case that the winding angle of the second flat belt 242 which is worn around the driven pulley 251 is increased, as shown in Fig. 21, the rotation shaft (input shaft) 220 of the driving pulley 221 is provided 20 with the free rotating member 200, which is freely rotatable and is positioned in a coaxial manner to this rotation angle 220. The second flat belt 242 is wounded with respect to this free rotating member 200, and whereby the winding angles of the second flat belt 242 with respect to the driven pulley 25 232 and the driven pulley 251 increases, while such an extra

tension pulley supporting member is not provided and also the space is not required.

[0099]

Incidentally, as apparently from the foregoing 5 descriptions, the belt driving apparatus 160 (namely, mode using free rotating members 200) of this embodiment may be applied to the belt driving apparatus of the image forming apparatus according to the embodiment 2.

[0100]

10 O Embodiment 8

Fig. 22(a) shows an embodiment 8 of a belt driving apparatus to which the present invention is applied.

The belt driving apparatus 100 according to this embodiment, as well as is arranged in a substantially similar to that of 15 the embodiment 1. The belt driving apparatus 100 drives the respective photosensitive drums 11 (11K to 11C), the first intermediate transfer drums 31a, 31b, and the second intermediate transfer drum 32. This belt driving apparatus 100 is provided with two flat belts 401 and 402 and various sorts of tension 20 members on which these flat belts 401 and 402 are tensioned or worn.

In this case, as the above-described tension member, there are driven pulleys 111 to 117 and tension pulleys 121 and 122 for circulating the respective flat belts 401 and 402. The 25 driven pulleys 111 to 117 are mounted on one ends of the

photosensitive drums 11 (11K to 11C), the first intermediate transfer drums 31a and 31b, and the second intermediate transfer drum 32 along axial directions thereof, respectively.

Incidentally, in this embodiment, the driven pulley 117 mounted on the second intermediate transfer drum 32 has a two-stage belt hanging plane over which the first flat belt 401 and the second flat belt 402 are hung, respectively.

[0101]

In particular, as shown in Fig. 22(b), the flat belts 401 and 402 employed in this embodiment are manufactured in such a manner that portions of two belt members 411 and 412 are fixed and are superimposed with each other.

Then, in this embodiment, plural columns of through holes 130 formed in the flat belts 401 and 402 are arranged, and plural columns of pulley projections 140 are arranged. However this embodiment is not limited to these arrangements.

Alternatively, the shapes of these through holes, the arrays of these through holes, the shapes of the pulley projections, and the arrays of the pulley projections may be freely designed.

20 [0102]

Next, a detailed description will now be given on an engagement (meshing) condition between the flat belts 401 and 402 and the pulley projections 140 in the belt driving apparatus 100 according to this embodiment.

25 For instance, as represented in Fig. 23(a), an engagement

between the flat belts 401/402 and the pulley 111 and the like in which load torque is produced is made in contact with one side of a through hole 130.

Since clearances D1 and D2 are provided in the dimensions 5 of the through hole 130 and of the pulley projection 140, the through holes 130 formed in the flat belts 401 and 402 are made in contact with the projections 140 of the pulley 111 and the like along a depression (tensile) direction due to the load.

10 In accordance with this embodiment, as shown in Fig. 23(b), since two sheets of the belt materials 411 and 412 are overlapped with each other in order to double the thickness of the flat belts 401 and 402, deformation of the hole portions of the through holes 130, which is caused by the engagement, can be 15 suppressed.

Incidentally, as to the flat belts 401 and 402 of this embodiment, since two sheets of the belt members 411 and 412 are overlapped with each other in such a manner that these flatbelts can be independently deformed in expansion/depression 20 manners, the bending rigidity of these flat belts 401 and 402 is substantially equal to that of a single belt member, so that these flat belts 401 and 402 can be wound on the pulley 111 and the like under stable conditions.

[0103]

25 On the other hand, as to flat belts 401' and 402' made

of one sheet of a belt member, as indicated in Fig. 24, in such a case that a strength of a hole portion of a through hole 130 cannot endure a magnitude of load torque, this hole portion of the through hole 130 is deformed in such a manner 5 that this hole portion rides over the projection 140 of the pulley 111 and the like. Then, when the deformed hole portions of the through holes 130 formed in the flat belts 401' and 402' are separated from the pulley 111 and the like, this deformation is recovered.

10 However, in the case that the magnitude of this deformation excessively becomes large, the hole portions of the through holes 130 formed in the flat belts 401' and 402' are plastic-deformed, as indicated by symbol "A" in Fig. 24. Then, after subsequent engagement, the deformed hole portions of 15 the through holes 130, which are not recovered, are engaged with the pulley projections 140. As a result, rotation amounts transferred to the pulley 111 and the like are fluctuated. Also, since the deformation/recovery operations are repeatedly carried out during the belt drive operation, the strengths 20 of the hole portions of these through holes 130 formed in the flat belts 401' and 402' are gradually lowered. In the worst case, there is such a risk that a crack is produced in the hole portions of the through hole 130, and thus, these flat belts are destroyed.

25 [0104]

Also, in this embodiment, Fig. 25 shows a manufacturing example of the above-described flat belts 401 and 402.

This example shows such an example that after two sheets of belt materials 411 and 412 are overlapped with each other 5 so as to align edge portions thereof, these aligned edge portions are coupled to each other by way of welding process and the like.

In this case, in order to adjust a positional relationship between these two belt members 411 and 412, or in order to 10 prevent deterioration of the effects achieved in this embodiment in such a case that the meandering directions of these flat belts 401 and 402 are different from each other, the welding process and the like are carried out to couple these edge portions.

However, in such a case that the widths of the flat belts 15 401 and 402 are short, since a difference between peripheral lengths of both sides of these flat belts 401 and 402 can be made small, there is no fluctuation in meandering directions which occur due to the difference between the peripheral lengths.

As a consequence, there is a rare case that the two sheets 20 of belt members 411 and 412 are meandered along different directions. In substantially all cases, since the flat belts are meandered by inclining pulleys, the two sheets of belt members 411 and 412 worn on the same pulley will be meandered along the same direction.

25 In such a case, the two sheets of belt members 411 and

412 can be independently used, while the edge portions of these belt members are not coupled to each other. Incidentally, since the positional shifts of the through holes 130 must be avoided, at least a portion of these through holes 130 must 5 be fixed.

[0105]

In the example shown in Fig. 25, the sheet-shaped belt members 411 and 412 are overlapped, while the lengths of these two sheets are adjusted and the pitches of the through holes 10 thereof are adjusted. Then, both the edge portions of these belt members 411 and 412 abut against each other, and are welded at the same time. As a result, the two sheets of belt members 411 and 412 can be coupled to each other at the welding portion.

To avoid such a possibility that a stepped portion is 15 produced in the welding portion, as illustrated in this drawing, it is preferable to conduct butt welding. Also, although only one portions of these belt members are welded in this example, a plurality of portions thereof may be welded. Furthermore, instead of welding, the two sheets of belt members 411 and 20 412 may be coupled to each other by employing adhesive agent.

For instance, when these belt members 411 and 412 are welded, as represented in Fig. 26, the welding operation is carried out by using a welding apparatus 420, while employing a jig 421 used for positioning positions of the through holes 25 and also intervals of the through holes. As a consequence,

it is possible to suppress distortions occurred during the welding operation, as well as fluctuations in positional relationships among these through holes.

[0106]

5 [Example]

O EXAMPLE 1

While the image forming apparatus according to the embodiment 1 is employed as an experiment model, the Inventors of the present invention actually investigated concentration 10 fluctuations in output images and positional shifts in images.

As a result of their experiments, even under such a condition that driven pulley shaft torque was given by which a flat belt having no hole was could not be driven, this image forming apparatus could succeed to reduce both the concentration 15 fluctuations in the output images and the positional shifts of the images lower than, or equal to recognizable limit values.

One example of the above-described examples is shown in Fig. 27.

In this drawing, while a variation in engagements between 20 through hole portions of a belt and projections of a pulley could be reduced up to $\Delta V_0 - p < 0.3\%$ which is a target level, a fluctuation in image concentration could be reduced lower than, or equal to the recognizable limit value.

[0107]

25 Also, in accordance with this example, an adverse influence

caused by belt meanders which were produced by increasing belt initial tension could be reduced.

One example is shown in Fig. 28. Incidentally, a result of comparative examples (belt though hole is one-column hole) 5 is shown in Fig. 29.

First, considering the comparative example, Fig. 29 shows progress in rotation fluctuation levels when a belt is continuously driven as follows: That is, 1) belt tension is increased from " T_0 " to " T_1 " without applying a load to a driven 10 pulley (see region "C1"). 2) Next, the belt tension is returned to " T_0 ", only a load equal to a half of a target value is applied to the driven pulley, and the belt tension is increased from " T_0 " to " T_1 " in a similar manner to the previous case (see region "C2"). 3) Furthermore, the belt tension is returned to " T_0 ", 15 a load equal to the target value is applied to the driven pulley, and the belt tension is increased from " T_0 " to " T_1 " (see region "C3").

[0108]

As apparent from this drawing, when the belt tension is 20 changed from the item 1) to the item 2), it can be seen that although the belt tension is returned to the initial condition, the level of the rotation fluctuation is not returned to the initial condition. This reason is given as follows. This is not an adverse influence due to the load because the item 1) 25 is no load drive, but an adverse influence cased by that the

belt meandering operation occurs, which gives the damage to the hole portions of the through holes when the belt tension is increased up to " T_1 ".

Also, in the items 2) and 3) where the load is given to 5 the driven pulley, it can be seen that the rotation fluctuation level is gradually deteriorated, and therefore, the adverse influence caused by the load is mixed with the adverse influence caused by the belt meandering operation.

After the experiment has been accomplished, when the hole 10 portions of the belt through holes are observed, the damage produced by engaging the hole portions of the belt through-holes cause the hole portions to be plastic-deformed, and cracks are produced in a certain hole portion. If such a phenomenon occurs, then it is practically difficult to play a role as 15 apparently an image forming apparatus, and further, a driving force transmission apparatus.

[0109]

To the contrary, Fig. 28 shows progress in rotation fluctuation levels when the belt is continuously driven as 20 follows, into which this example has been conducted: That is, 1) while belt tension is set to " T_0 ", a load given to a driven pulley is gradually increased from 0 to the target value (see region "A1"). 2) Next, the belt tension is returned to " T_0 ", the belt tension is set to T_1 ($T_0 \times 1.4$), and a load given to 25 the driven pulley is gradually increased from 0 to the target

value (see region "A2"). 3) Furthermore, after the belt tension is returned to " T_0 ", the belt tension is set to T_2 ($T_0 \times 1.7$), and the load given to the driven pulley is gradually increased from 0 to the target value (see region A3).

5 As apparent from this drawing, when the load given to the driven pulley is increased, there is such a trend that the rotation fluctuation is slightly deteriorated. However, the level of this deteriorated rotation fluctuation is small.
Also, there is substantially no adverse influence caused by
10 the belt meandering operation which is produced by increasing the belt tension. In other words, while the experiment is carried out, in a case that the belt tension is returned to the initial condition so as to set no load condition, the level of the rotation fluctuations is also returned to the initial
15 condition, resulting in reproducibility.

Conversely, since the belt tension is increased, the gripping force exerted between the pulley and the flat belt is increased, and the rotation fluctuation caused by the engagement between the pulley and the flat belt may be reduced.

20 As a consequence, since this example 1 is conducted, " $\Delta V_0 - p$ " corresponding to the concentration fluctuation recognizable limit value of the output image could be reduced smaller than, or equal to 0.3% and a driving force transmission system having higher reliability with respect to the load and the belt
25 meandering operation could be provided.

[0110]

o Example 2

The image forming apparatus according to the embodiment
7 is employed as an experiment mode and the Inventors of the
5 present invention actually investigated concentration
fluctuations in output images and positional shifts in images.
In accordance with the experiment performed by the Inventors,
even when a mode uses a flat belt having no hole, since a winding
angle of the flat belt with respect to a pulley can be sufficiently
10 increased, a slip occurred between the flat belt and the pulley
can be effectively avoided.

Even under such a condition that driven pulley shaft torque
was given by which a flat belt having no hole was slipped and
could not be driven, this image forming apparatus could succeed
15 to reduce the concentration fluctuations in the output images
and the positional shifts of the images lower than, or equal
to recognizable limit values.

One example is shown in Fig. 30.

In this drawing, while a variation in engagements between
20 through hole portions of a belt and projections of a pulley
could be reduced up to $\Delta V_0 - p < 0.3\%$ which is a target level,
a fluctuation in image concentration could be reduced lower
than, or equal to the recognizable limit value.

[0111]

25 [Effect of the Invention]

As previously described in detail, in accordance with the driving force transmission apparatus of the invention, the following effects can be achieved. That is, in the system for transferring the driving force by wearing an endless-shaped flat belt over a plurality of tension members, an improvement is made in the structures of the through holes which are arrayed in the flat belt along the travel direction thereof, and also in the structures of the projections formed on at least one of the plural tension members over which the flat belt is worn (namely, improvements in plural through holes, arrays of projections, and combinations between elongated-hole shaped through holes and pillar-shaped projections). While the engaging conditions between the through holes and the projections can be firmly maintained, the driving force transmission apparatus owns such a structure capable of avoiding concentration of the operation force onto the hole portions of the through holes. As a consequence, apparently, this driving force transmission apparatus can effectively prevent the slips occurred between the flat belt and the tension members, and also, can effectively distribute the force exerted to the hole portions of the through holes under such a condition that the heavy rotation load is applied to the driven member which is coupled to any one of the tension members. While the destruction of the hole portions of the through holes is effectively prevented, the driving force transmission apparatus can transfer the driving

force to the driven member under stable condition.

As a consequence, in the image forming apparatus with employment of such a driving force transmission apparatus, since the destruction of the hole portions of the through holes formed in the flat belt having the through holes can be effectively suppressed, and also, the driving force can be stably transferred to the image carrier corresponding to the member to be driven, this image forming apparatus can produce the output image without any image defect, while the lifetime of this flat belt having the through holes can be extended.

[0112]

Also, in accordance with the driving force transmission apparatus of the present invention, the following effects can be achieved. That is, in the system for transferring the driving force by wearing the endless-shaped flat belt over a plurality of tension members, while the free rotating member which can be freely rotated is provided in the coaxial manner with respect to the rotation shaft of at least one tension member among the plural tension members to which the driving force is transferred, the flat belt is worn via the free rotating member with respect to the adjoining tension members which are different from such a tension member where this free rotating member is provided. As a consequence, for example, the winding angle of the flat belt with respect to the adjoining tension members can be set to the large angle. Moreover, the specific space

is no longer required to be formed as the setting space of this free rotating member.

As a result, in such an embodiment that, for instance, the member to be driven is coupled to at least one of these 5 adjoining tension members, even under such a condition that the heavy rotation load is applied to the member to be driven, the setting space for the auxiliary tension member supporting member used to wear the flat belt is not specifically required, and the driving force can be stably transferred to the member 10 to be driven without unnecessarily extending the layout space.

Moreover, in the image forming apparatus with employment of such a driving force transmission apparatus, the auxiliary tension member supporting member is not specifically required so as to wear the flat belt. In addition, since the driving 15 force can be transferred under stable condition to the image carrier corresponding to the member to be driven, this image forming apparatus can produce such an output image having no image defect, while avoiding such a problem that this image forming apparatus is made bulky.

20 [Brief Description of the Drawings]

Fig. 1 is an explanatory diagram for showing an outline of a driving force transmission apparatus according to the present invention.

Fig. 2(a) is an explanatory diagram for showing an outline 25 of a driving force transmission apparatus according to another

mode of the present invention, and Fig. 2(b) is an explanatory diagram for showing a major portion thereof.

Fig. 3 is an explanatory diagram for showing an outline of a driving force transmission apparatus according to a further
5 mode of the present invention.

Fig. 4 is an explanatory diagram for showing an entire structure of an image forming apparatus according to an embodiment 1.

Fig. 5 is a perspective explanatory diagram for showing
10 a driving force transmission apparatus employed in the embodiment 1 in detail.

Fig. 6(a) is an explanatory diagram for showing a front view of the driving force transmission apparatus employed in the embodiment 1, and Fig. 6(b) is an explanatory diagram for
15 showing a plan view thereof.

Fig. 7(a) is an explanatory diagram for showing a major portion of the driving force transmission apparatus employed in the embodiment 1, Fig. 7(b) is a diagram viewed from a direction "B" of Fig 7(a), and Fig. 7(c) is a diagram viewed from a direction
20 "C" of Fig. 7(a).

Fig. 8(a) is an explanatory diagram for showing an engagement state between through holes of flat belts and projections of pulleys in a comparison mode, Fig. 8(b) is an explanatory diagram for showing an engagement state between
25 through holes of flat belts and projections of pulleys in this

embodiment, Fig. 8(c) is an explanatory diagram for showing an engagement state between through holes of flat belts and projections of through holes in a modified mode of this embodiment when the flat belt is meandered; and Fig. 8(d) is an explanatory 5 diagram for showing an engagement state between through holes of flat belts and projections of through holes in this embodiment when the flat belt is meandered.

Fig. 9 is an explanatory diagram for showing a modified mode of the driving force transmission apparatus employed in 10 the embodiment 1.

Fig. 10 is an explanatory diagram for showing an overall structure of an image forming apparatus according to an embodiment 2.

Fig. 11(a) to Fig. 11(b) are explanatory diagrams for 15 showing both a driving force transmission apparatus and modified embodiments thereof, according to an embodiment 3.

Fig. 12 is an explanatory diagram for showing a driving force transmission apparatus according to an embodiment 4.

Fig. 13(a) is an explanatory diagram for showing a tension 20 roller employed in this embodiment, Fig. 13(b) is an explanatory diagram for showing a shape of a flat belt employed in this embodiment, and Fig. 13(c) is an exploded perspective view of this tension roller.

Fig. 14 is an explanatory diagram for showing operations 25 of the driving force transmission apparatus according to this

embodiment.

Fig. 15 is an explanatory diagram for showing a major portion of a driving force transmission apparatus according to an embodiment 5.

5 Fig. 16(a) is an explanatory diagram for showing a major portion of a driving force transmission apparatus according to an embodiment 6, and Fig. 16(b) is an explanatory diagram for showing operation of this driving force transmission apparatus.

10 Fig. 17 is an explanatory diagram for showing a major portion of an image forming apparatus according to an embodiment 7.

15 Fig. 18 is a perspective explanatory diagram for showing an outline of a driving force transmission apparatus employed in the embodiment 7.

Fig. 19 is a perspective explanatory diagram for showing the driving force transmission apparatus employed in the embodiment 7, as viewed from a rear surface side of Fig. 18.

20 Fig. 20(a) is an explanatory diagram for showing a concrete example of a free rotating member, and Fig. 20(b) is an explanatory diagram for showing an example of position restrictions with respect to an axial direction of the free rotating member.

25 Fig. 21 is an explanatory diagram for showing a modified mode of a driving force transmission apparatus employed in the embodiment 7.

Fig. 22(a) is an explanatory diagram for showing a driving force transmission apparatus according to an embodiment 8, and Fig. 22(b) is an explanatory diagram for showing a structure of a flat belt employed in this embodiment.

5 Fig. 23(a) is an explanatory diagram for showing a portion near through holes of the driving force transmission apparatus according to this embodiment, and Fig. 23(b) is an explanatory diagram for showing operations of the driving force transmission apparatus according to this embodiment.

10 Fig. 24 is an explanatory diagram for showing operations of a driving force transmission apparatus according to a comparison mode.

Fig. 25 is an explanatory diagram for representing a manufacturing method of a flat belt employed in this embodiment.

15 Fig. 26 is an explanatory diagram for showing in detail an edge portion welding step in the manufacturing method of the flat belt shown in Fig. 25.

Fig. 27 is an explanatory diagram for showing a rotation fluctuation in a driven pulley employed in a driving force
20 transmission apparatus according to an example 1.

Fig. 28 is an explanatory diagram for showing a drive result of the driving force transmission apparatus according to the example 1.

Fig. 29 is an explanatory diagram for showing a drive
25 result of a driving force transmission apparatus according

to a comparative example.

Fig. 30 is an explanatory diagram for showing a rotation fluctuation in a driven pulley employed in a driving force transmission apparatus according to an example 2.

5 Fig. 31 is an explanatory diagram for showing problems of a driving force transmission apparatus according to a related art.

Fig. 32 is an explanatory diagram for showing a relationship between the concentration fluctuation allowable value and the 10 rotation fluctuation of an image carrier member in the image forming apparatus using the driving force transmission apparatus according to the related art.

Fig. 33 is an explanatory diagram for showing a relationship between the average rotation speed of the driven pulley and 15 the load torque in the driving force transmission apparatus according to the related art, using the flat belt.

Fig. 34 is an explanatory diagram for showing one example of the driving force transmission apparatus according to the related art, using the flat belt.

20 Fig. 35(a) is an explanatory diagram for showing another example of the driving force transmission apparatus according to the related art, using the flat belt, and Fig. 35(b) is a diagram for showing this driving force transmission apparatus, as viewed from the direction B of Fig. 35(a).

25 Fig. 36 is an explanatory diagram for showing a relationship

between the driven shaft load and the rotation average speed of the driven pulley in the driving force transmission apparatus related to Fig. 35.

[Description of the Reference Numbers]

- 5 1 flat belt
- 2(2a-2d) tension members
- 3 through hole
 - 3a elongated-hole shaped through hole
 - 3b circular-shaped through hole
- 10 4 projection
 - 4a pillar-shaped projection
 - 4b semi-spherical shaped projections
- 5 free rotating member

[Name of Document] Abstract

[Abstract]

[Purpose]

In a mode in which an endless-shaped flat belt is worn
5 over a plurality of tension members, while a transmission error
of driving force is eliminated caused by a slip between the
flat belt and the tension members such as pulleys, the driving
force is transferred under stable condition even under a
condition that a heavy load is given to a member to be driven.

10 [Solving means]

While plural columns of through holes 3 are formed in
at least one of flat belts 1 along a travel direction of the
flat belts 1, plural columns of projections 4 are provided
on at least one of tension members 2 along a rotation direction
15 of the tension member 2. This flat belt 1 is worn over these
tension members 2. The through holes 3 formed in the flat
belt 1 are fitted to these projections 4. Also, a free rotating
member 5 is mounted on at least one tension member 2a of the
plural tension members 2 to which the driving force is transferred.
20 This free rotating member 5 is freely rotatable and is positioned
in a coaxial manner with respect to a rotation shaft of this
tension member 2a. The flat belt 1 is worn via the free rotating
member 5 over such tension members 2b and 2c, which are different
from the tension member 2a on which this free rotating member
25 5 is mounted, and are located adjacent to each other (Fig.).

3). Further, an image forming apparatus with employment of these driving force transmission apparatus may be realized.

[Selected Drawing] Figure 1

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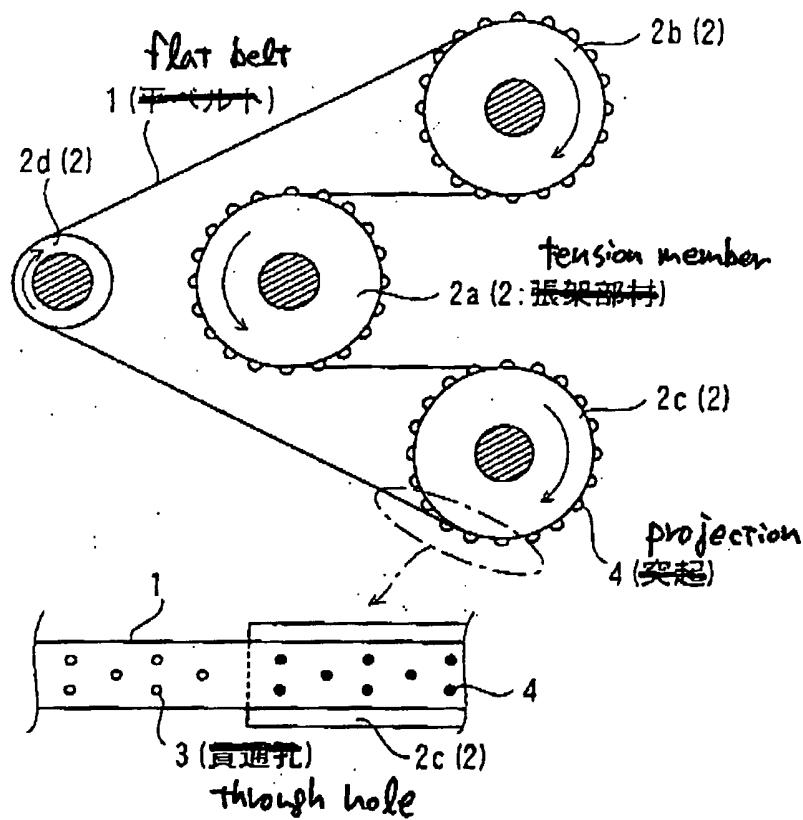
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[書類名]

図面 Drawings

[図1]

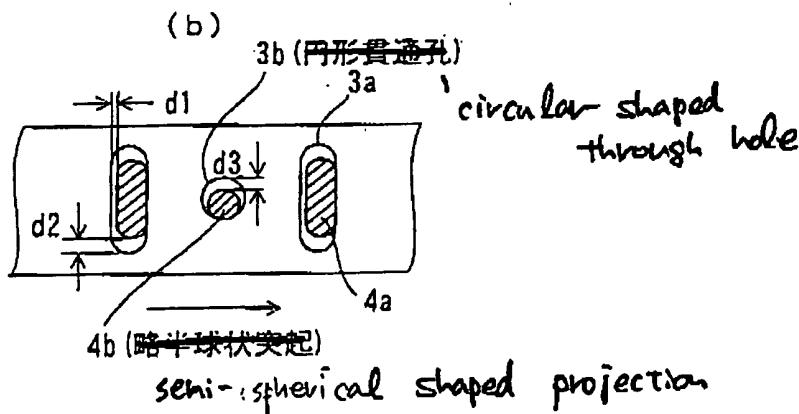
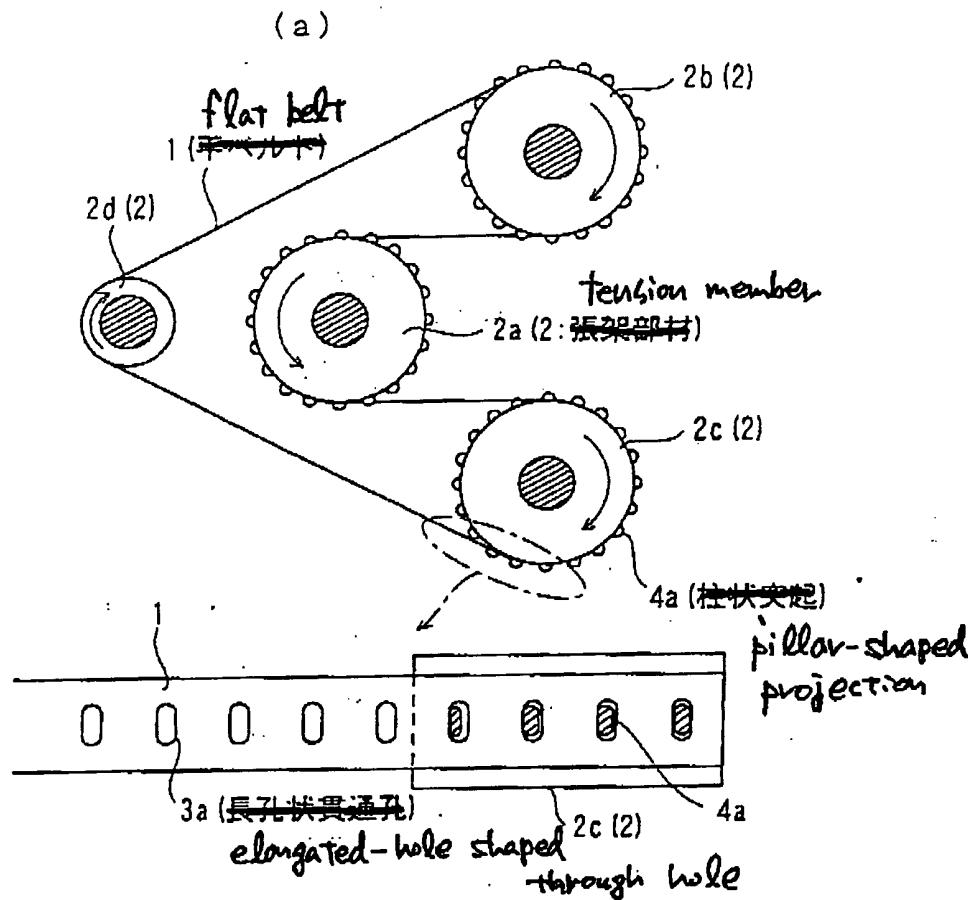
Fig. 1



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[図2]

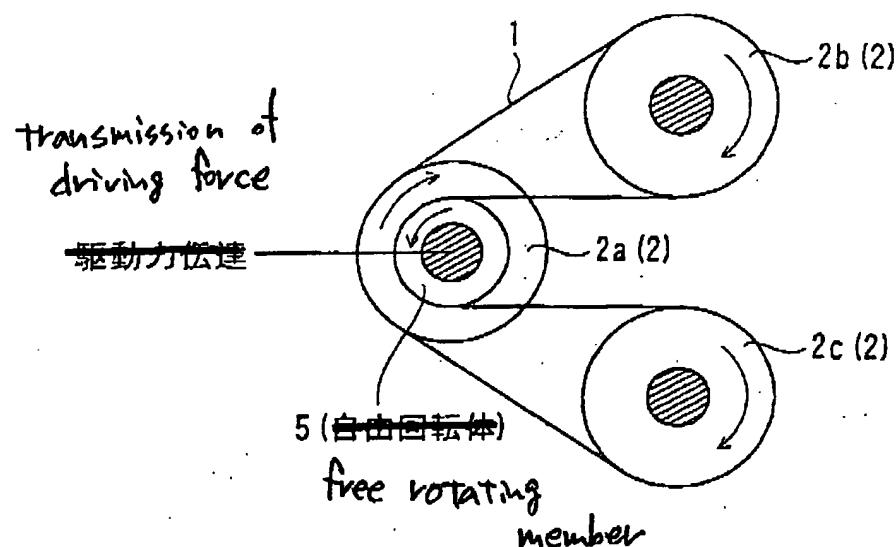


整理番号 = F E 0 1 - 0 0 7 5 5

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[図3]

Fig.3

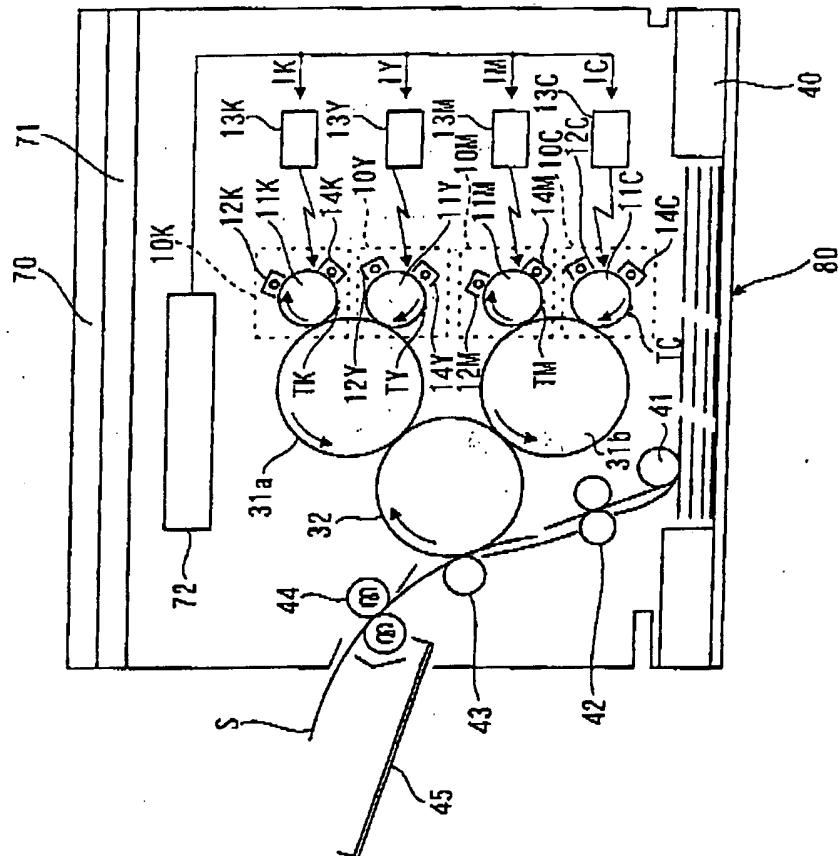


整理番号 = F E 0 1 - 0 0 7 5 5

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[圖4]

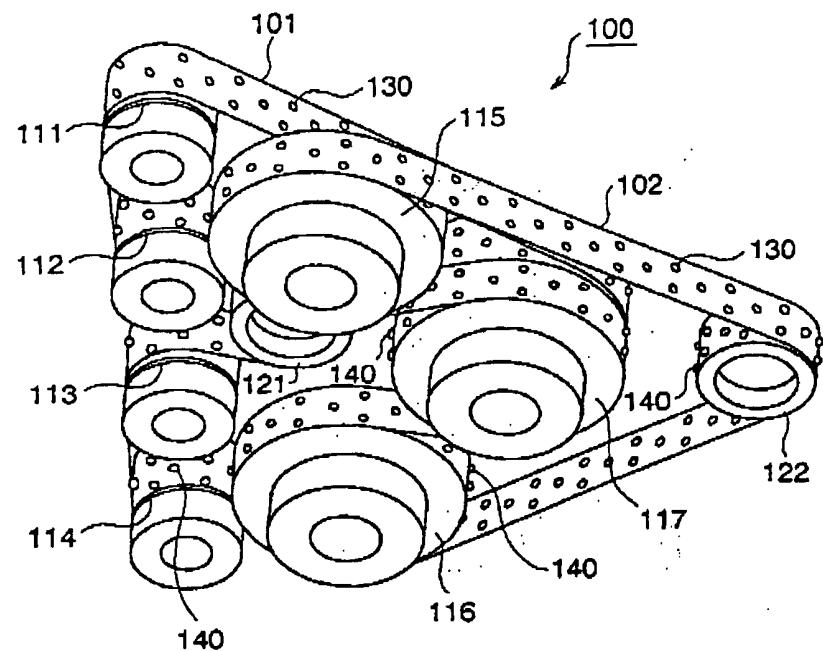
Fig. 4



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[図5]

Fig.5

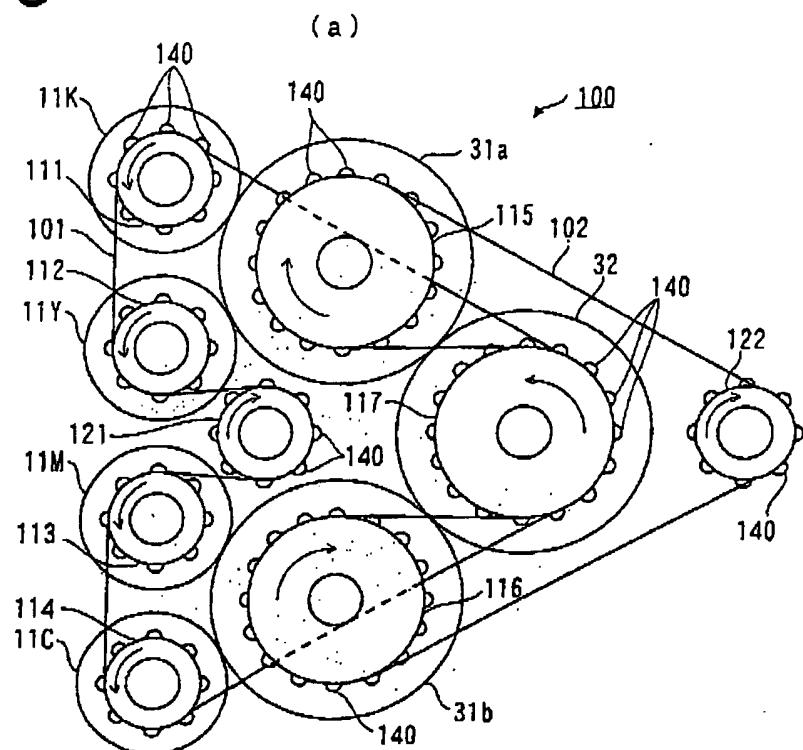


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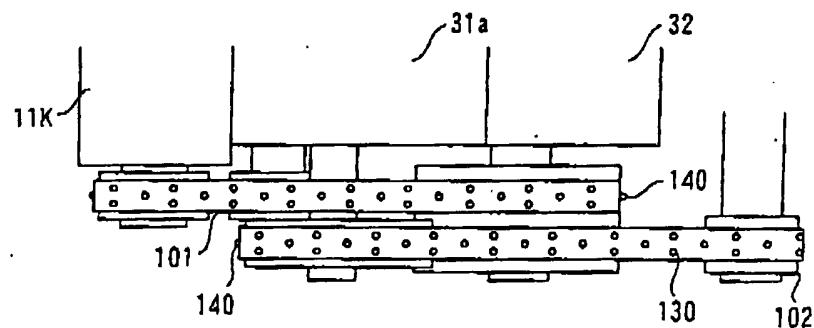
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【図6】

Fig. 6



(b)

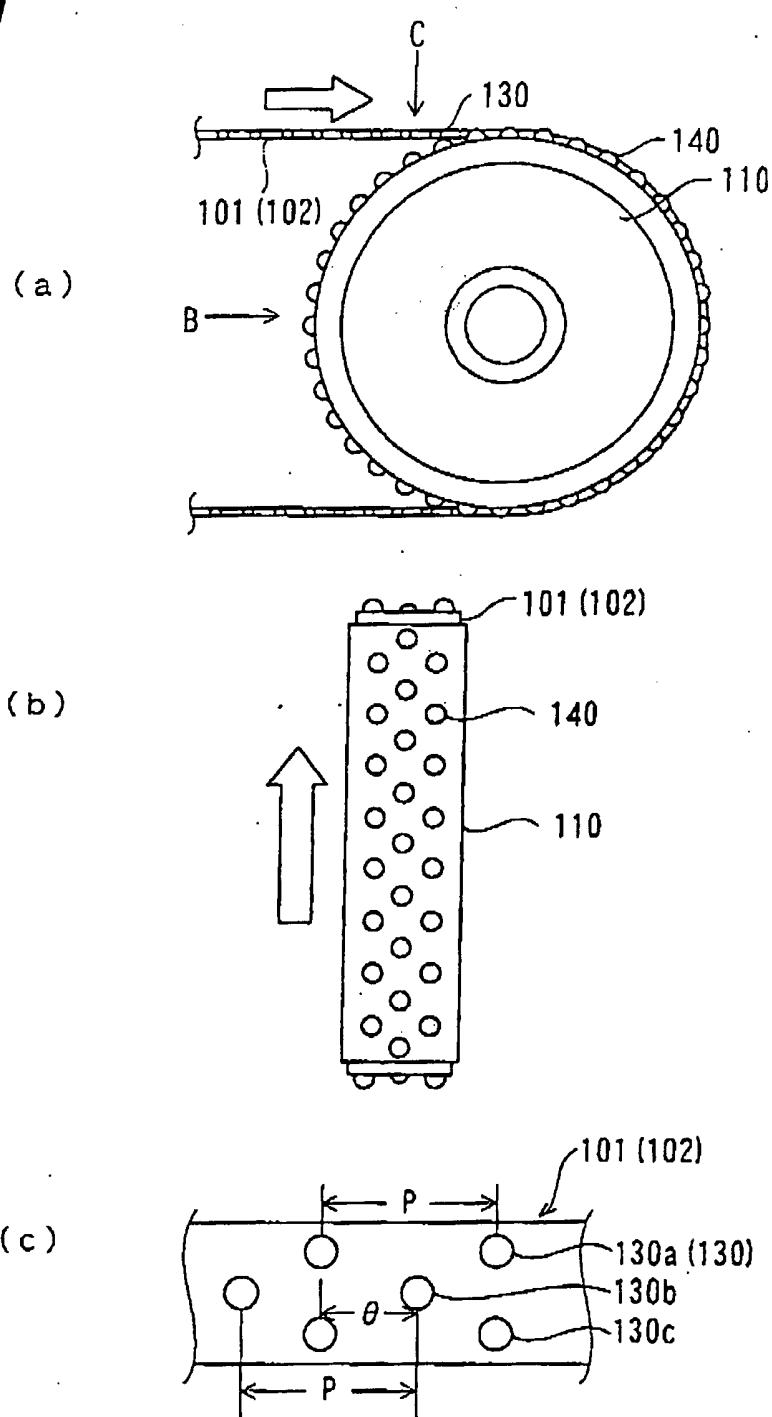


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[図7]

Fig. 7

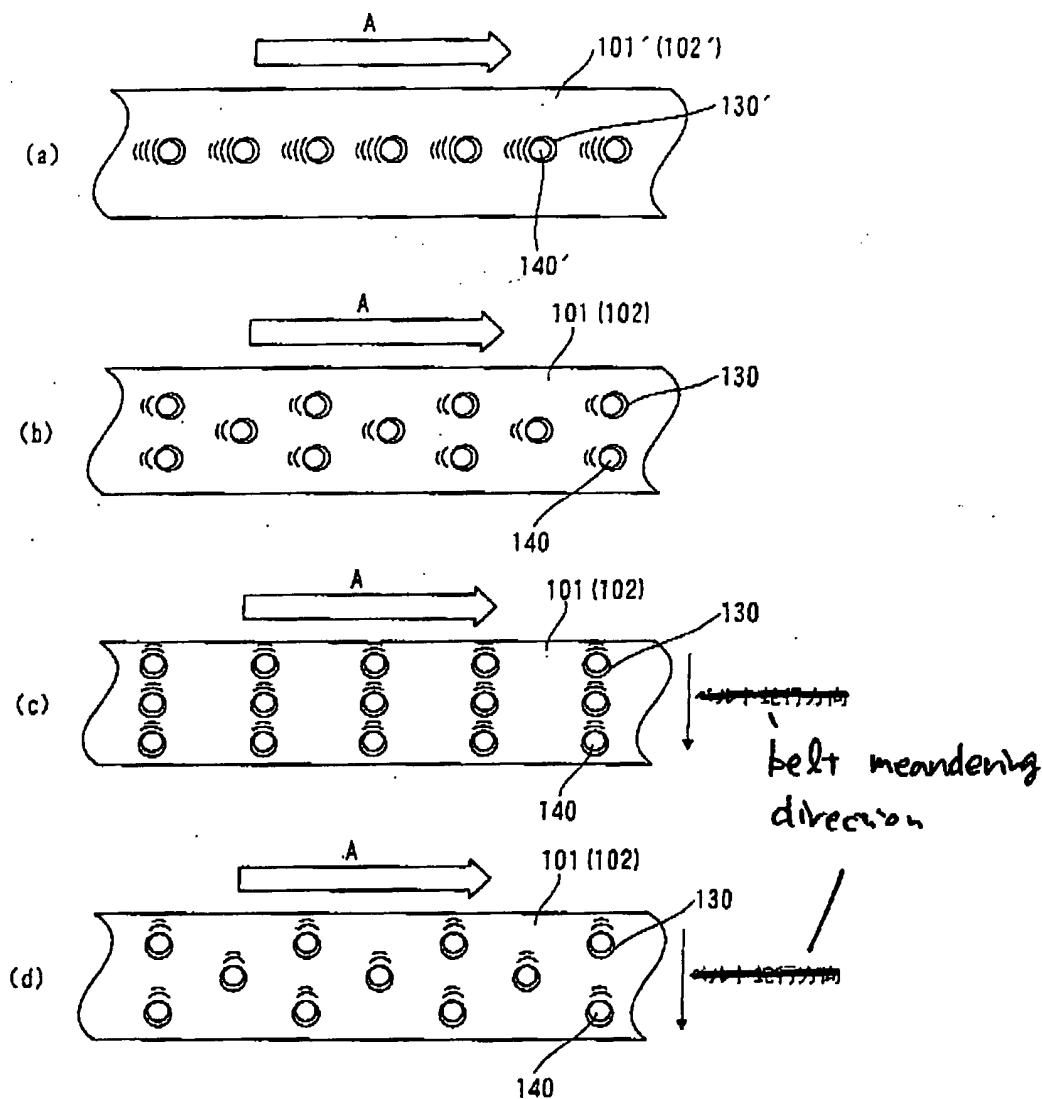


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[図8]

Fig. 8

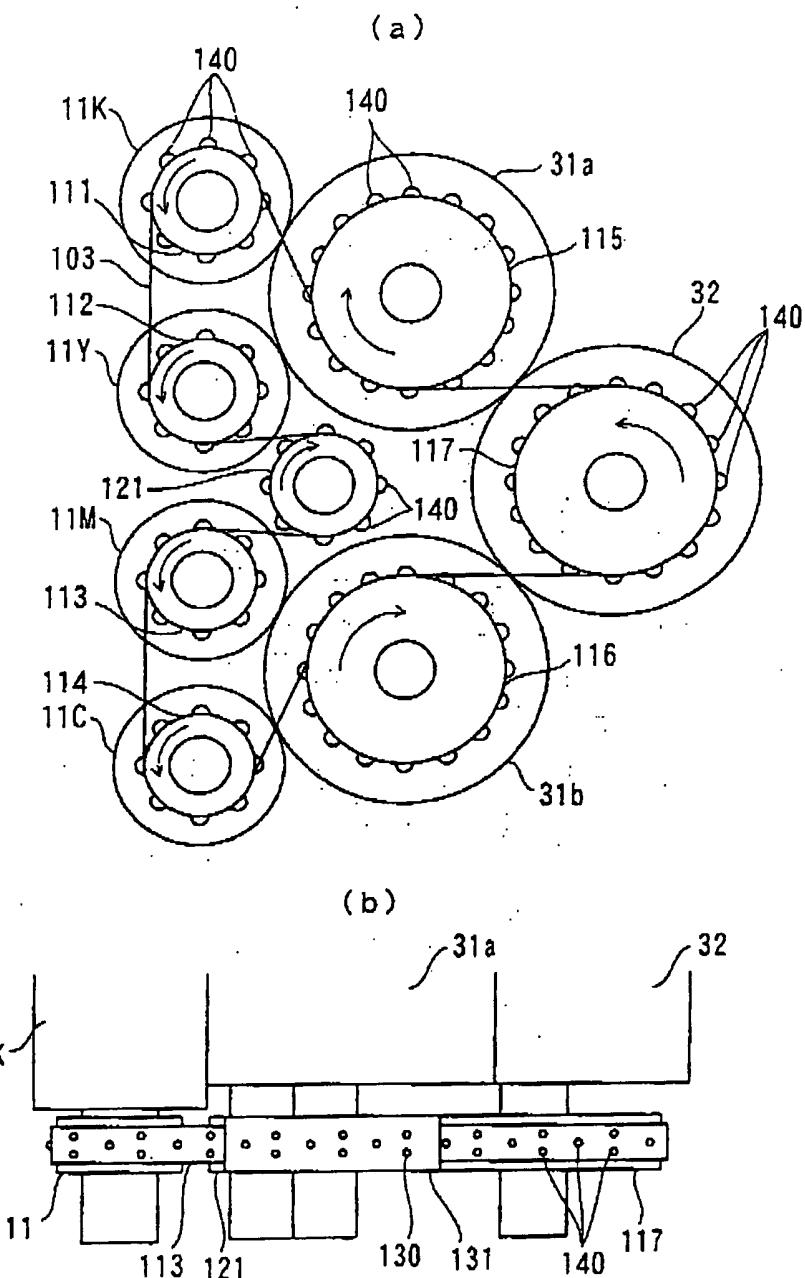


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[回分]

Fig. 9

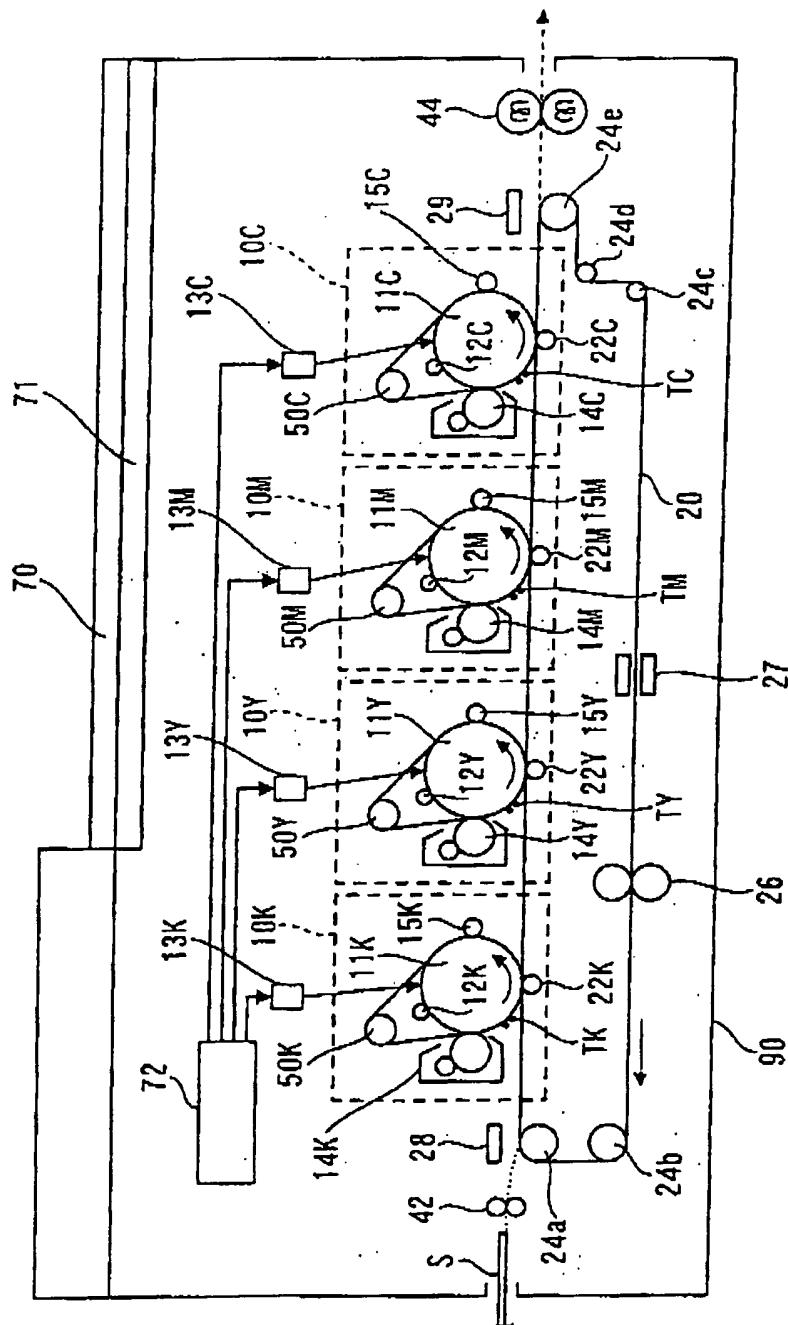


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[四一〇]

Fig. 10

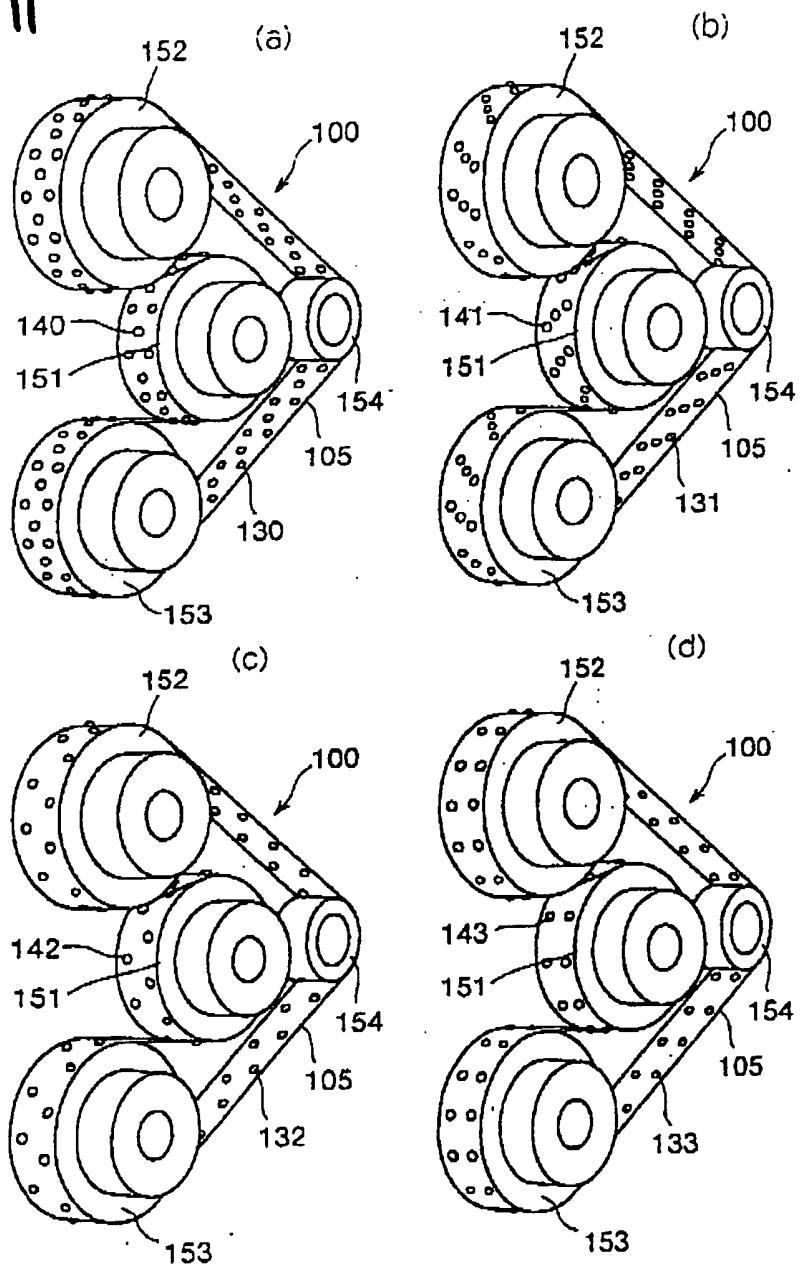


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【図11】

Fig. 11

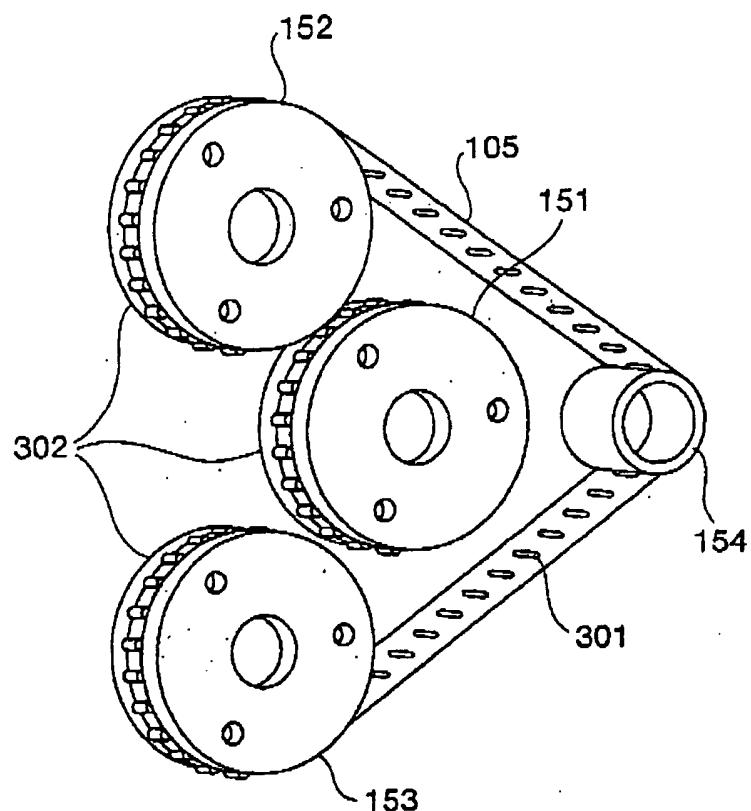


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[~~図12~~]

Fig. 12



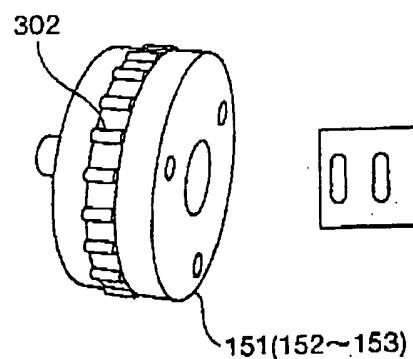
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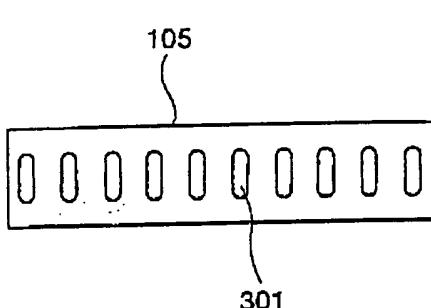
[図13]

Fig. 13

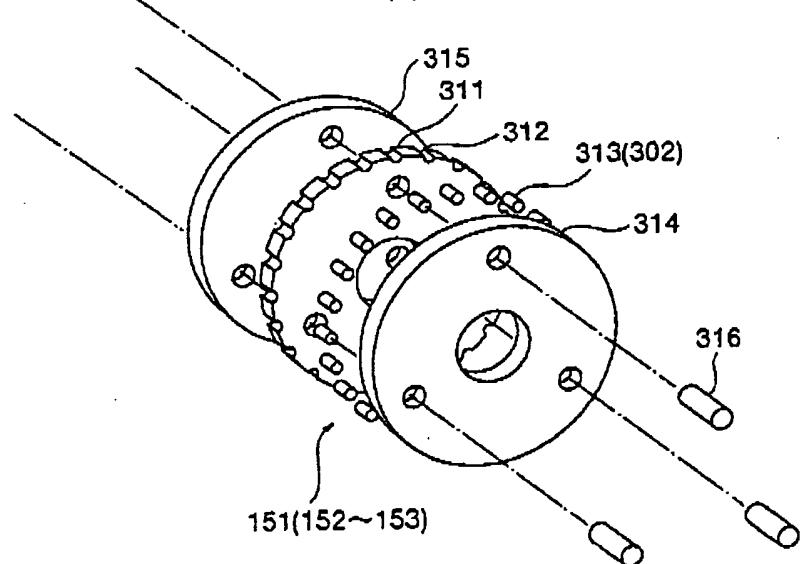
(a)



(b)



(c)

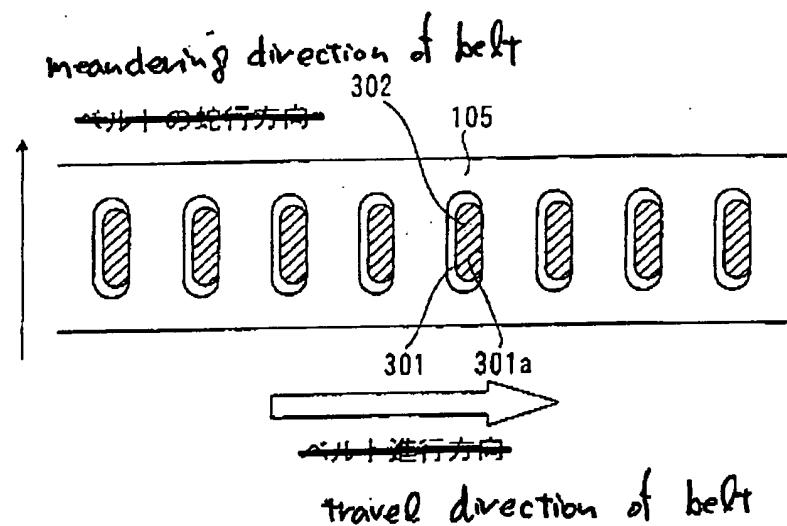


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[図14]

Fig. 14

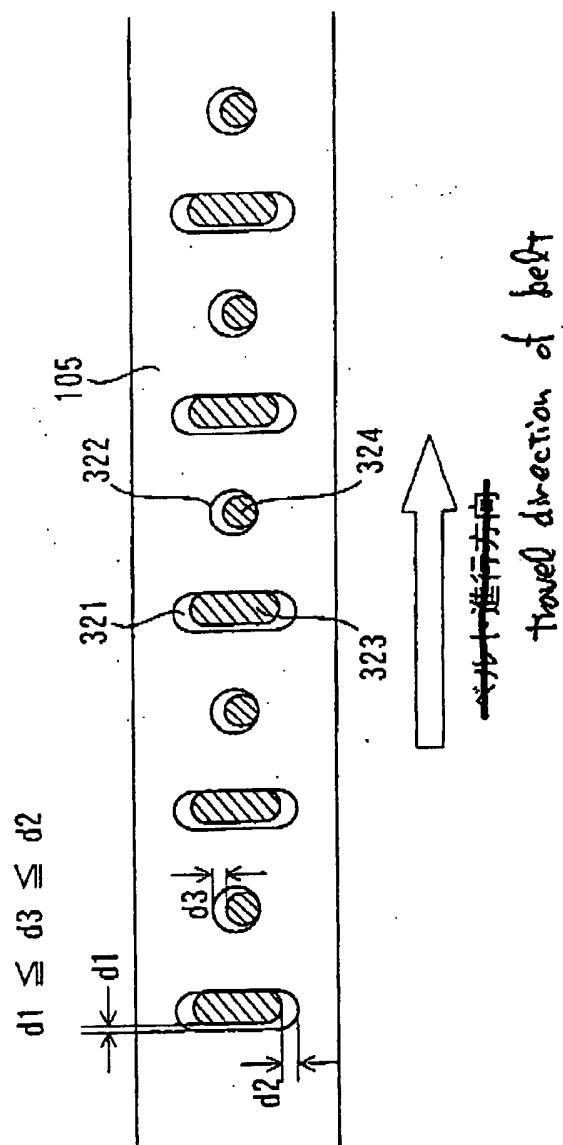


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[Fig. 15]

Fig. 15

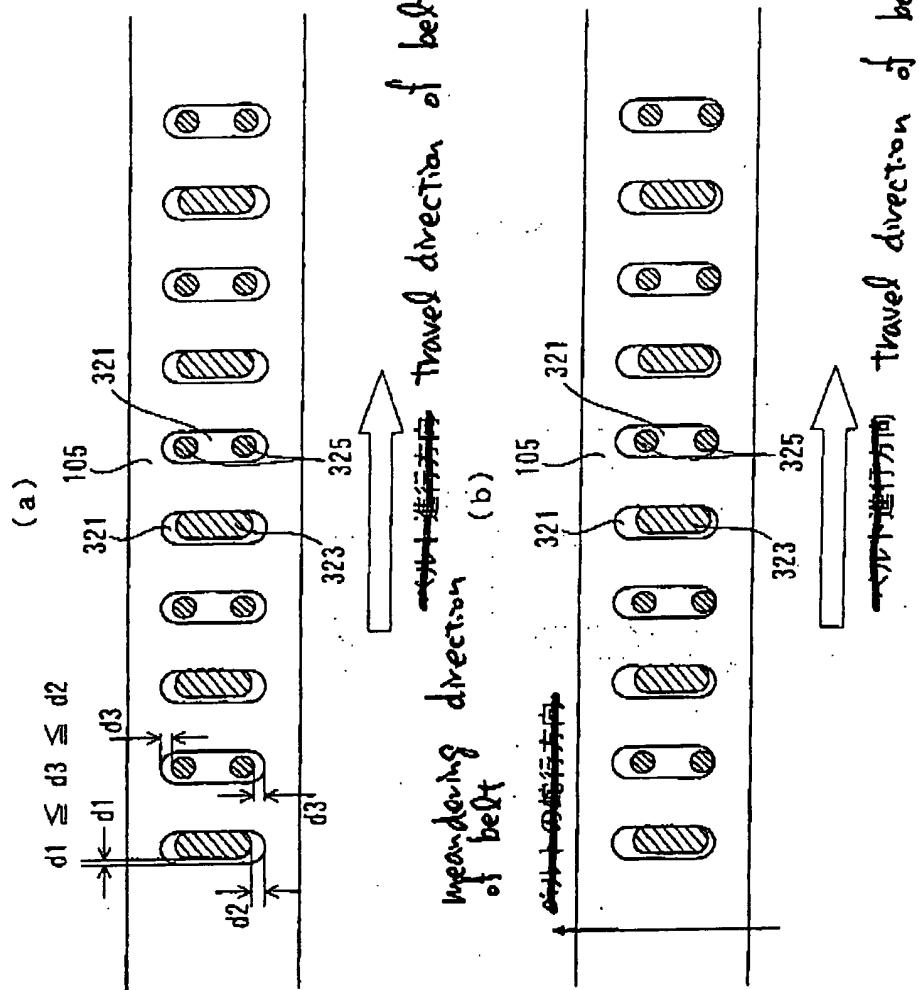


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[図16]

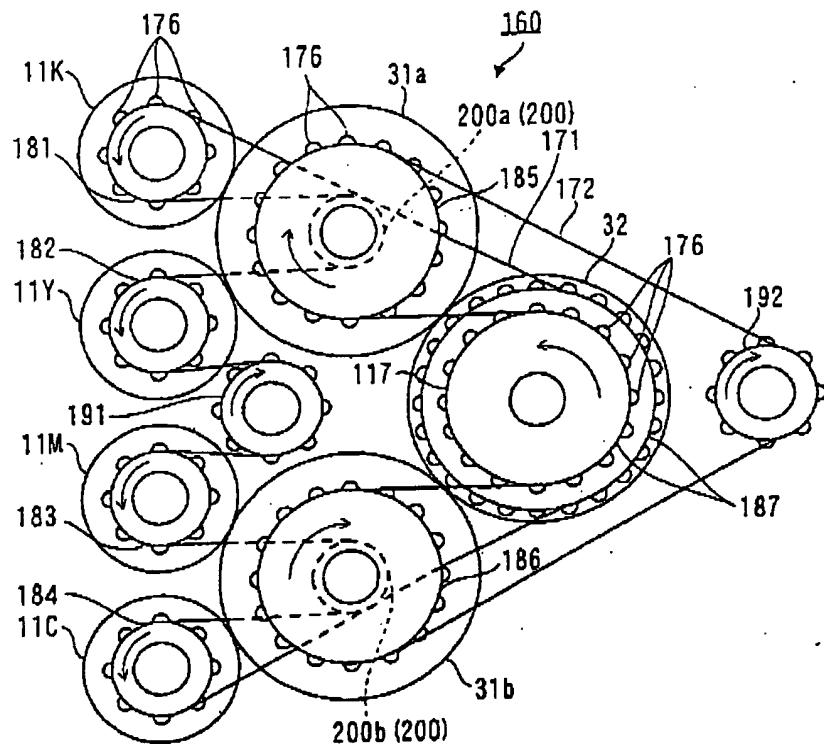
Fig. 16



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【図17】

Fig. 17

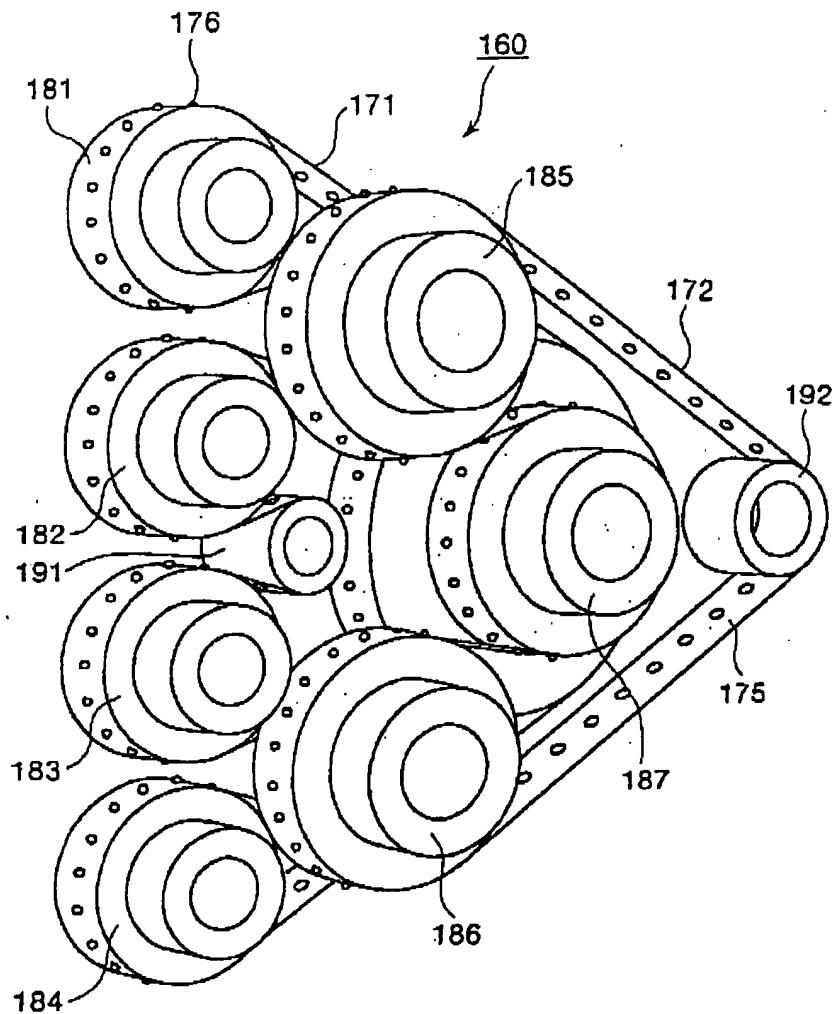


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【図18】

Fig. 18

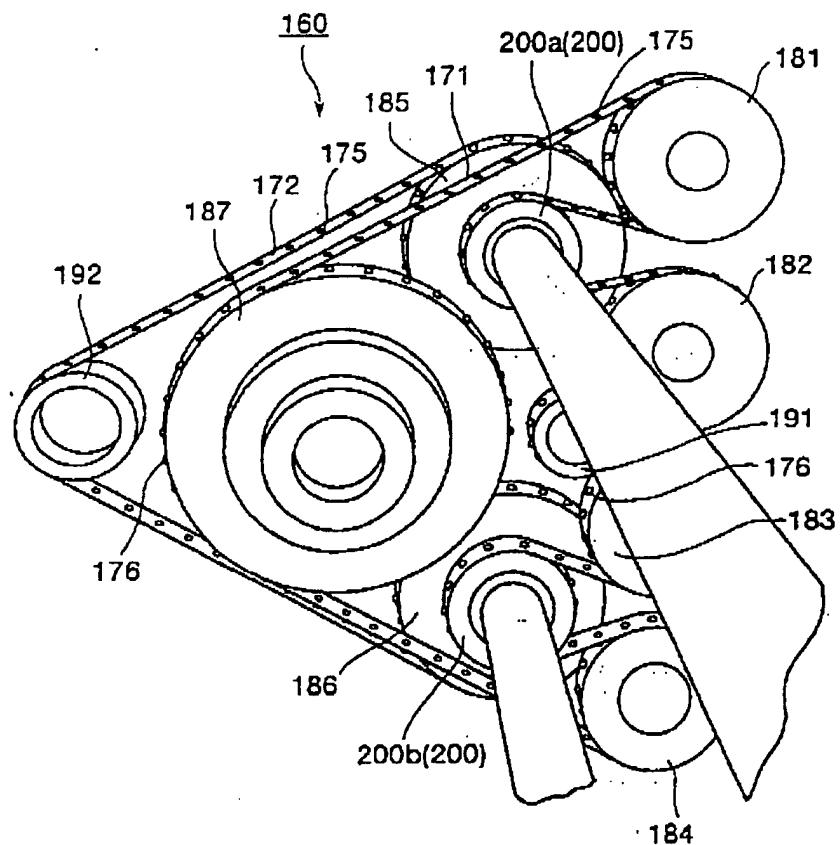


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[図19]

Fig. 19



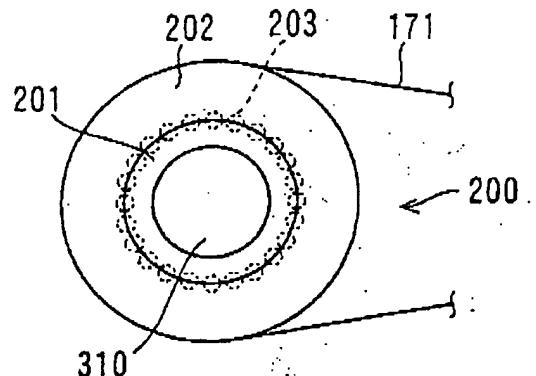
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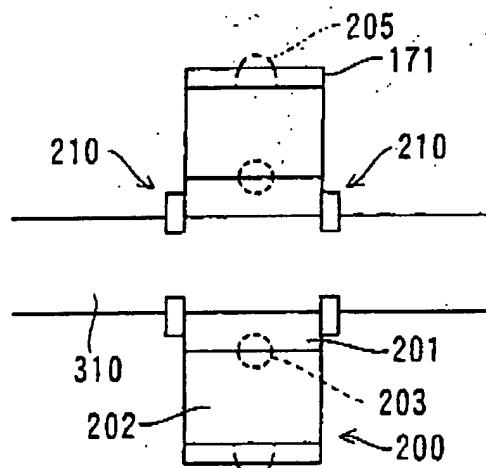
[図20]

Fig. 20

(a)



(b)

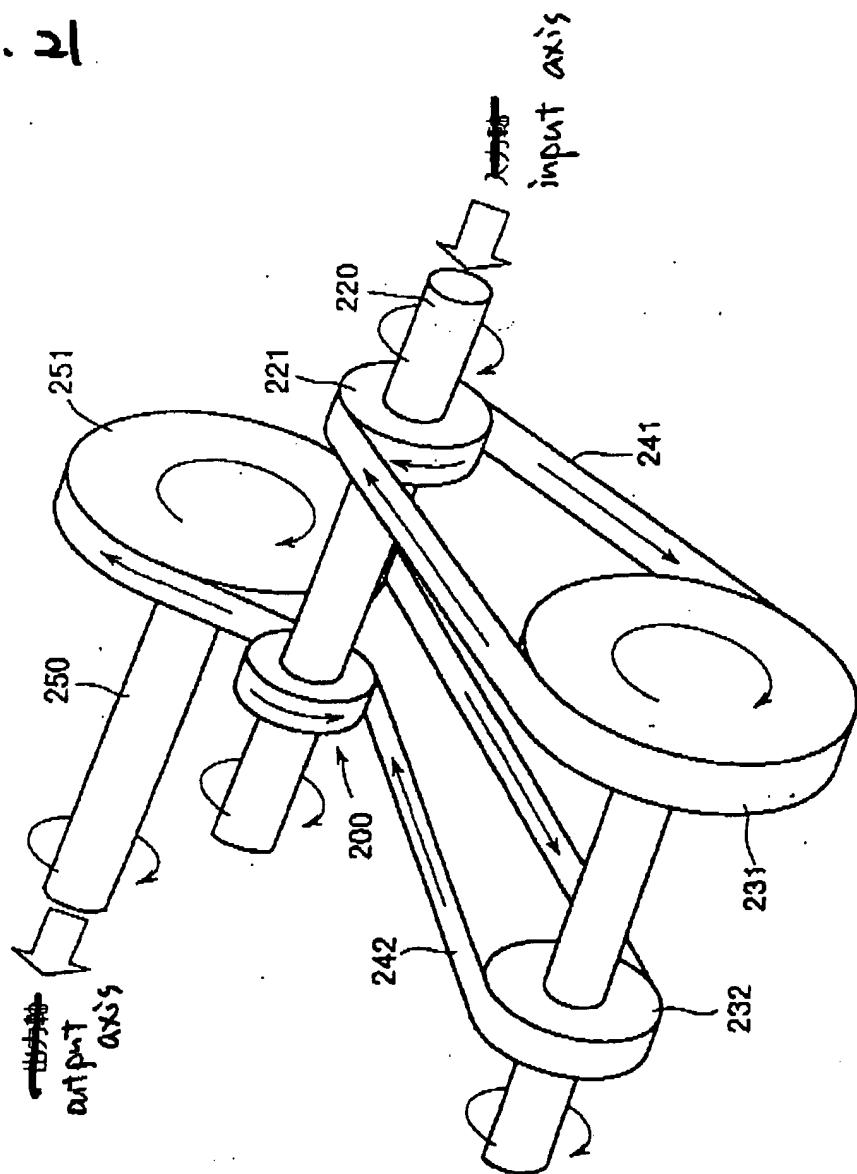


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[图21]

Fig. 21



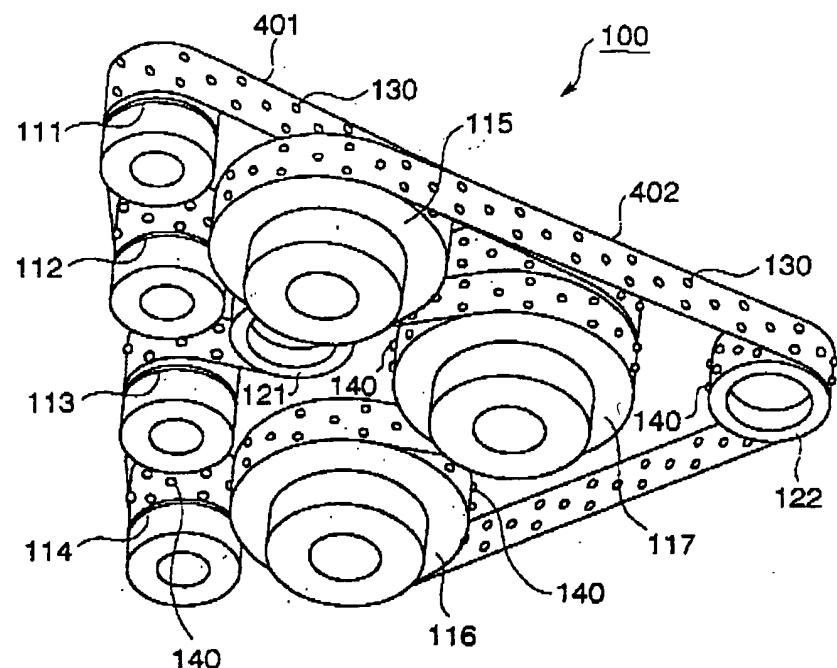
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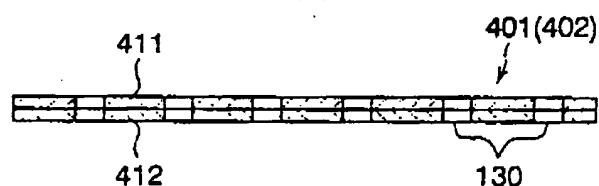
[222]

Fig. 22

(a)



(b)



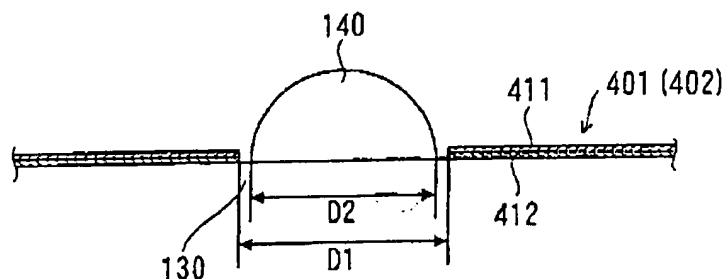
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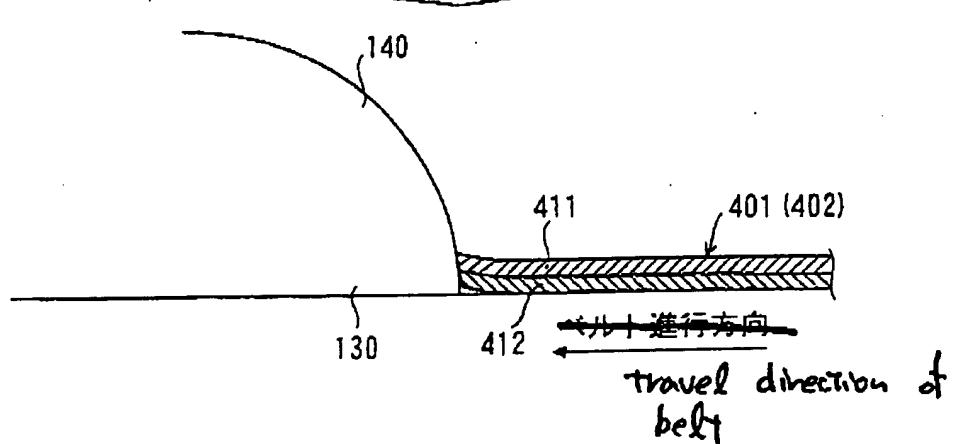
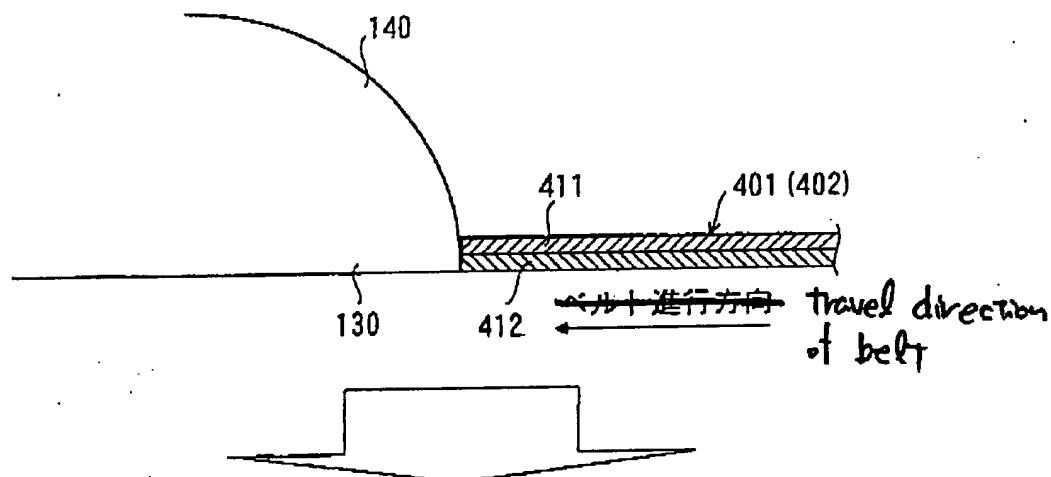
[図23]

Fig. 23

(a)



(b)

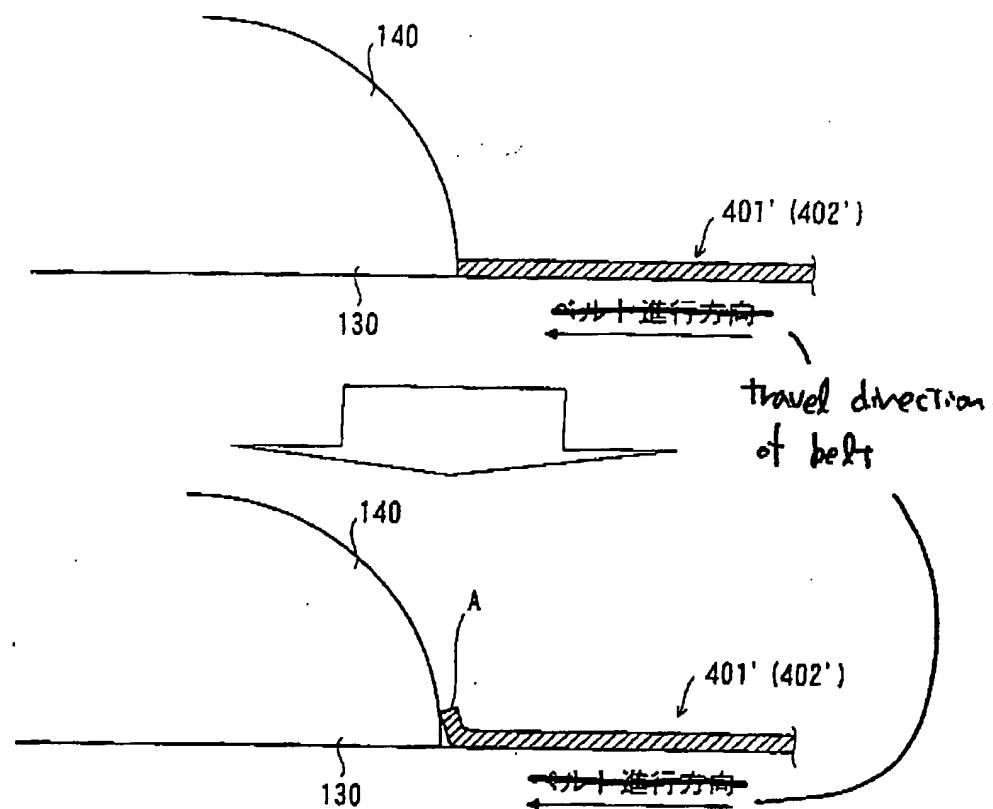


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〔図24〕

Fig. 24

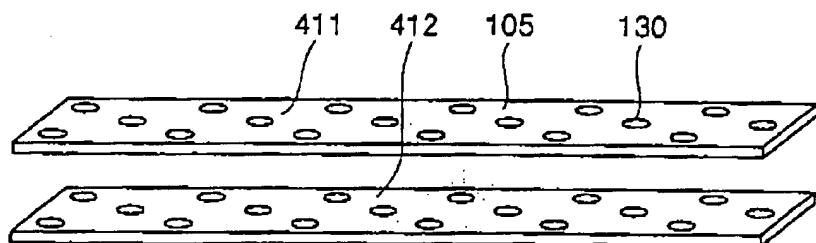


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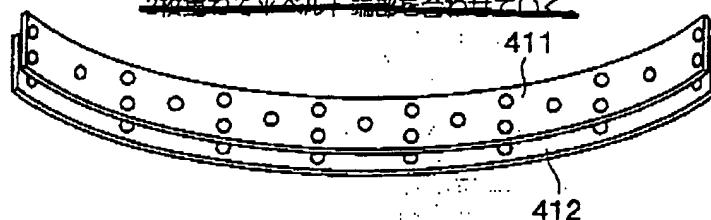
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[図25]

Fig. 25

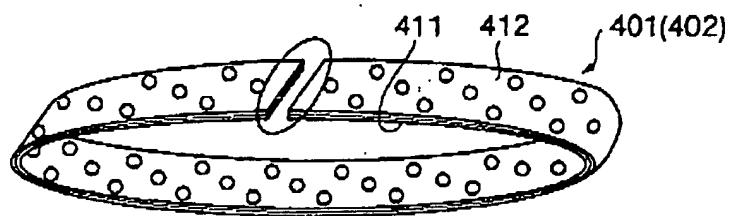


*overlap two sheets of flat belts with each other
to align end portions thereof*



end portions of two overlapped flat belts are abutted and welded

2枚重ねた平ベルト端部を重ね合わせ溶接する。

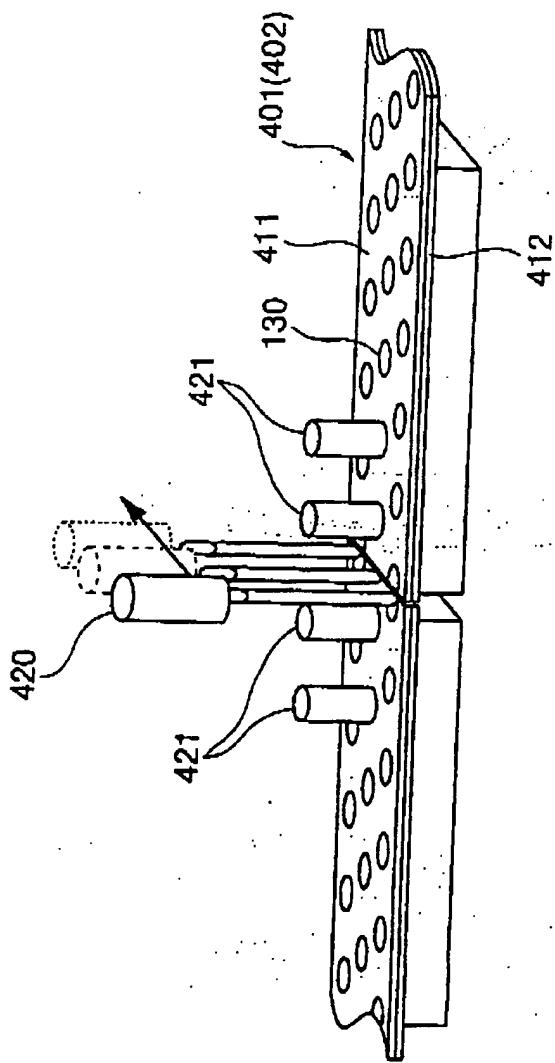


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(図26)

Fig. 26



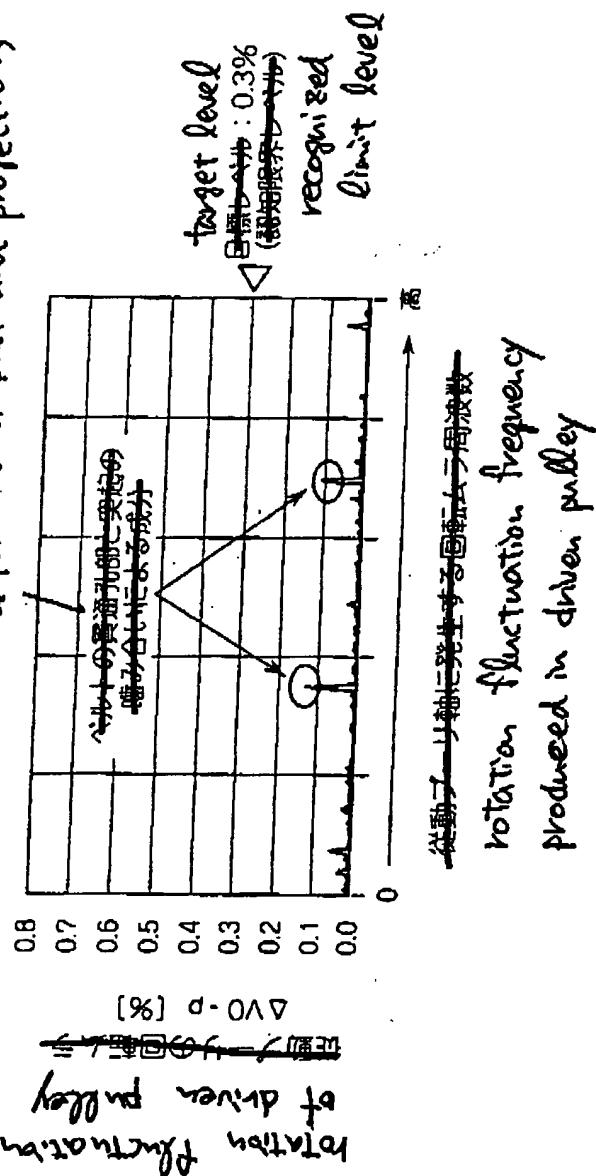
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[図27]

Fig. 27

Components produced from engagement between through hole
or portions of belt and projections



rotation fluctuation
of driven pulley

FIG.28

ΔVO-p OF ENGAGEMENT COMPONENT
BETWEEN THROUGH HOLE PORTIONS
AND PROJECTIONS [%]

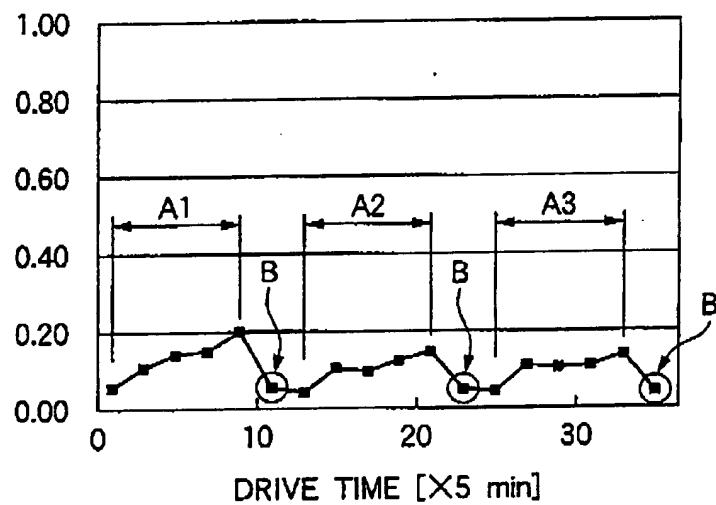
DRIVE RESULT IN PLURAL-COLUMN
HOLE TYPE IN EXAMPLE 1

FIG.29

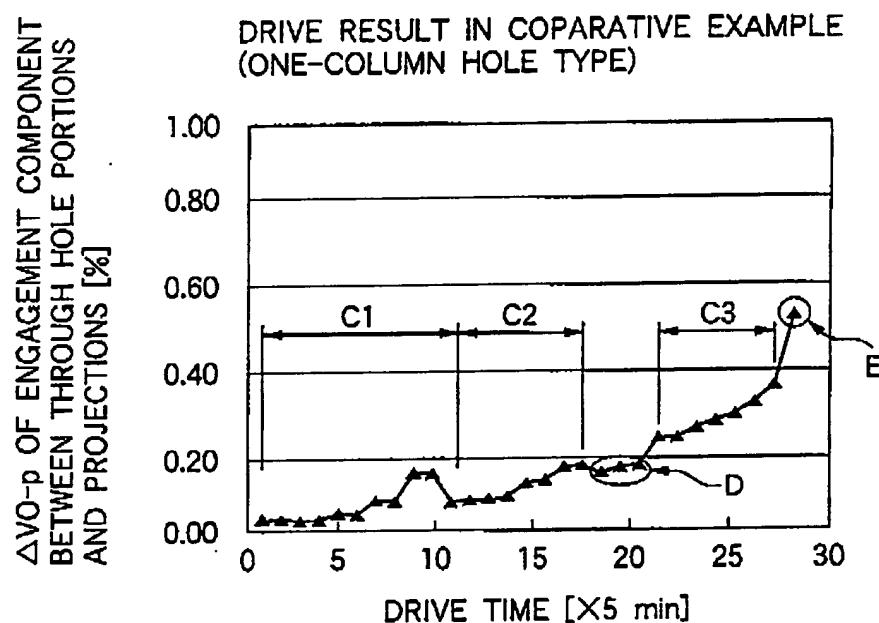


FIG.30

COMPONENTS PRODUCED FROM
ENGAGEMENT BETWEEN THROUGH HOLE
PORTIONS OF BELT AND PROJECTIONS

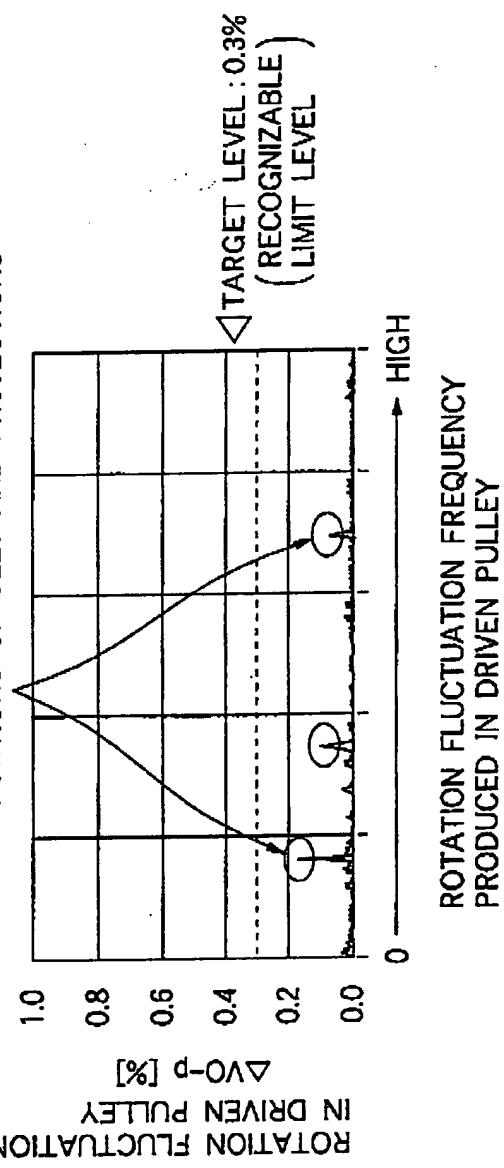


FIG.31

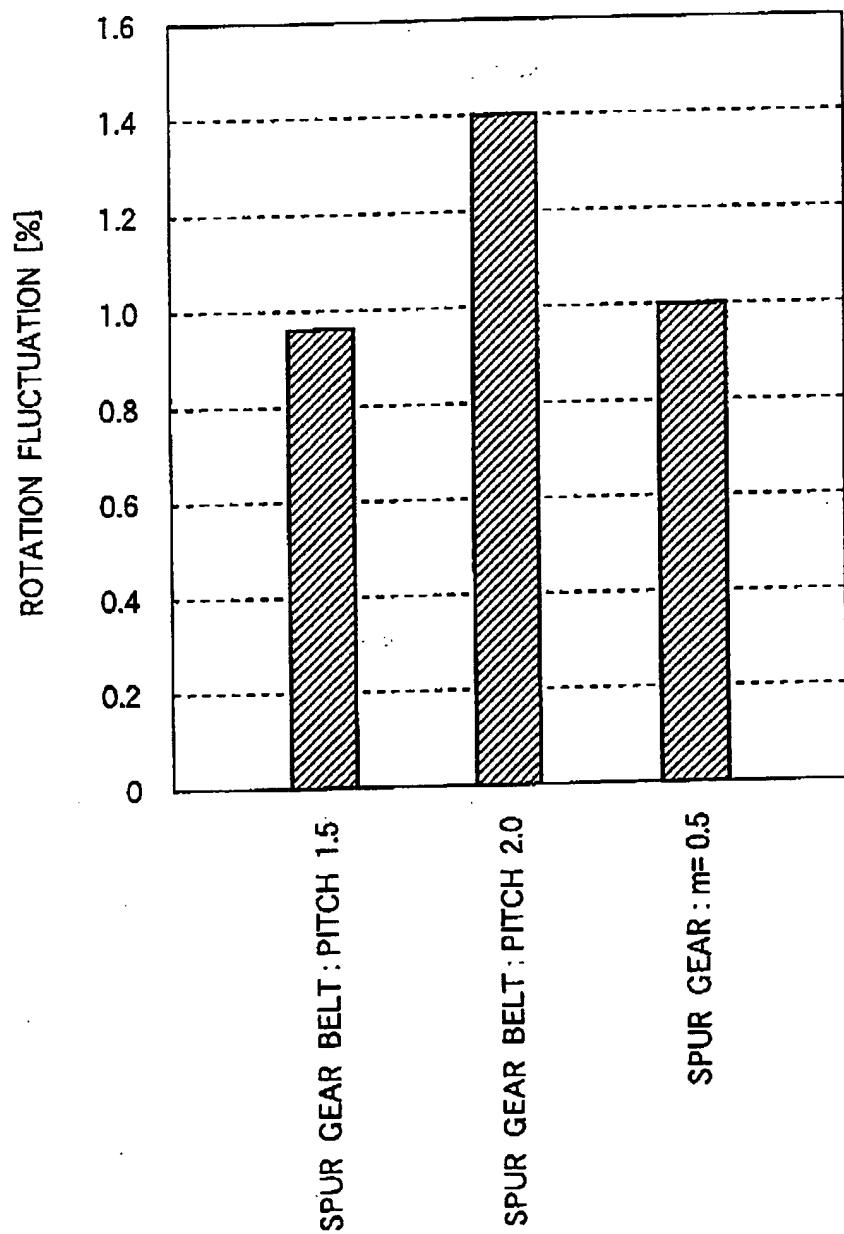


FIG.32

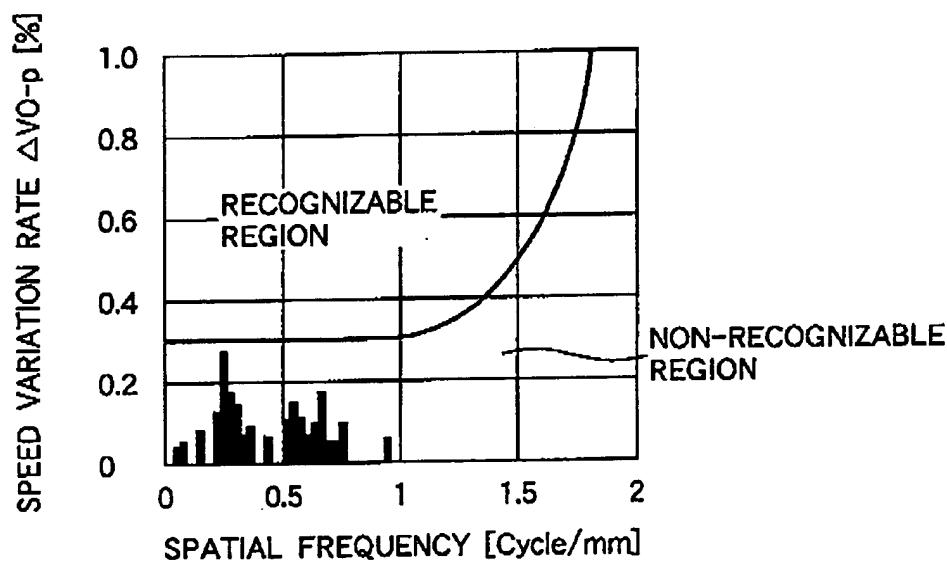


FIG.33

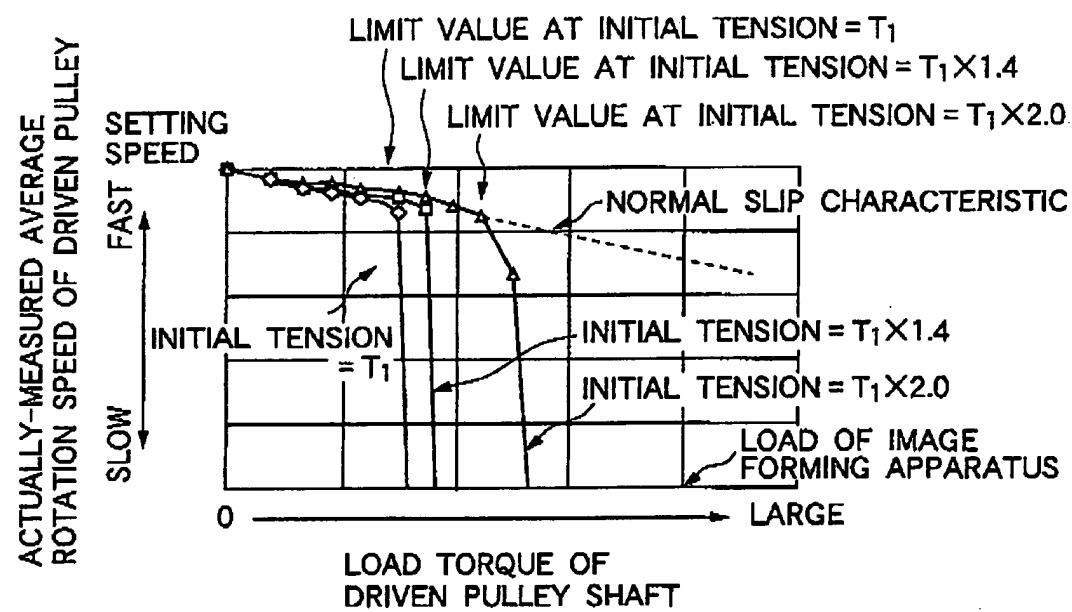
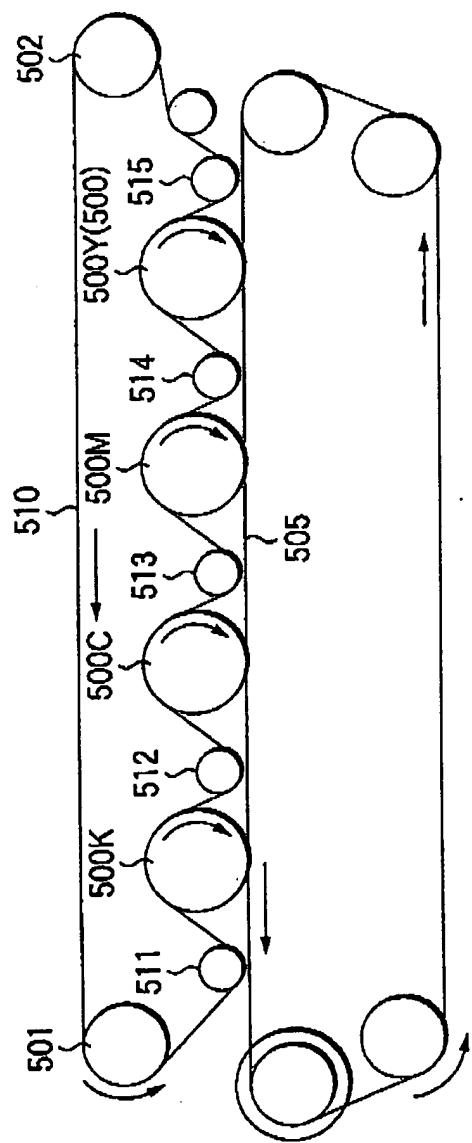


FIG.34

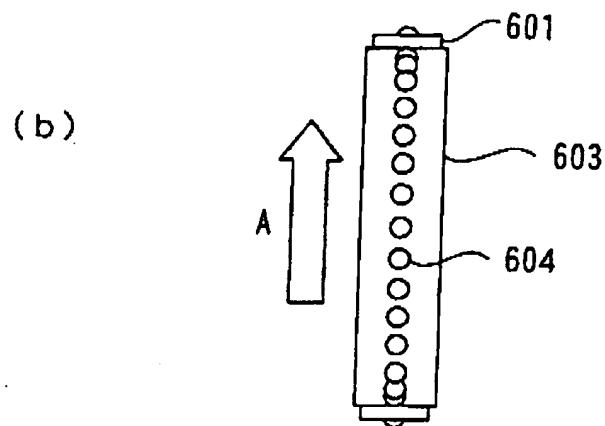
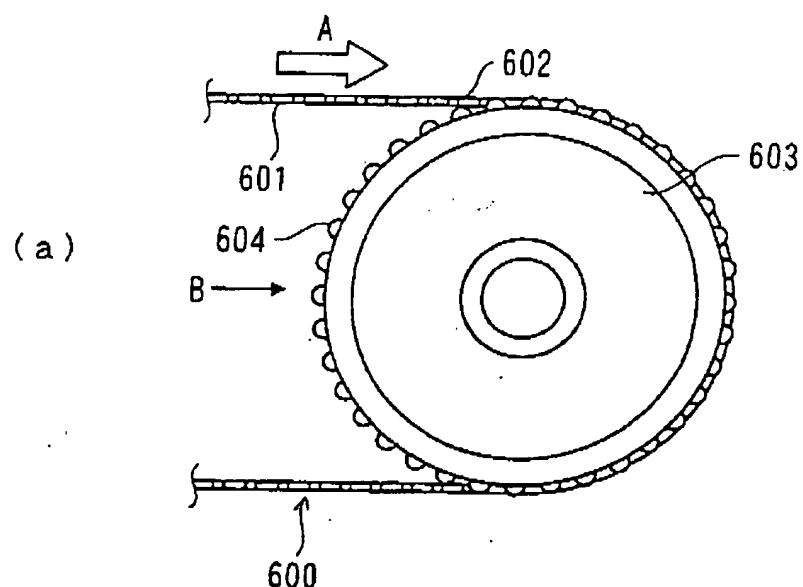


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(Fig. 35)

Fig. 35



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[Fig. 36]

Fig. 36

